FINAL TREATABILITY STUDIES PLAN

EG&G ROCKY FLATS

Environmental Restoration Program

August 26, 1991

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

Volume I

ADMIN RECORD

FINAL TREATABILITY STUDIES PLAN

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REVIEWED FOR CLASSIFICATION/UCNI
By F. J. Curran
Date 8-28-91

EXECUTIVE SUMMARY

This Treatability Studies Plan (TSP) is part of a comprehensive, phased program of remedial investigations, feasibility studies, and corrective/remedial actions currently in progress to address contamination at the Rocky Flats Plant. It was developed to meet the requirements of Article XI of the January 22, 1991 Final Inter-Agency Agreement (IAG). The Treatability Studies Plan has been designed to identify candidate technologies for use in corrective/remedial actions at the Rocky Flats Plant. The primary purpose of the TSP is to expedite the screening of technologies and alternatives for the types of contaminants that appear to be generally present at the site. In parallel with the Treatability Studies Program, feasibility studies for each of the individual operable units (OUs) at the Rocky Flats Plant will be conducted. The TSP will provide information to demonstrate whether or not certain technologies should be considered further for specific problems in the OU-specific feasibility studies. The information obtained from the sitewide and specific OU treatability studies will provide data to support the final remedy selection and design process. The full range of technologies potentially applicable to the types of waste and waste matrices included in this study are identified in the TSP and evaluated for suitability for implementation at Rocky Flats. This full range of technologies included both conventional technologies and innovative technologies. The evaluation of technologies for treatability testing in this sitewide program addresses contamination identified at two or more operable units. Results of the sitewide treatability tests will be used in the analysis of alternatives during the feasibility studies, and it is intended to provide information useful to remediation action studies for individual OUs. It does not preclude separate treatability studies which may be conducted for individual OUs.

This TSP provides background information on the Rocky Flats Plant (Section 2.0), a detailed discussion of program objectives (Section 3.0), and site contamination data (Section 4.0). The technology selection process (Section 5.1) is then described, followed by the Technologies Evaluation and Selection Summary (Section 5.2). This summary discusses the selection of target contaminants and the literature/database search used to identify the potentially applicable technologies. The identified technologies were then subjected to a preliminary screening to identify those technologies suitable for application at Rocky Flats. The technologies were identified and screened based on the potential for application to the following contaminant types and matrices present at Rocky Flats: volatile organic compounds, semivolatile organic compounds, inorganics, metals, and radionuclides; and in the soil, sediments, surface water, and groundwater matrices. Relative costs for the technologies selected for the sitewide treatability test program will be provided in annual reports. These costs will be considered in developing the priority and sequence for conducting the tests in conjunction with management and technical factors.

The technologies which passed the preliminary screening were subjected to a final screening. The final screening determined if the technology should be included in the sitewide treatability test program at this time. Statements of work were prepared for technologies selected for laboratory or bench scale testing. Treatability study work plans will be prepared for these technologies before the testing is implemented. The results of the treatability tests for these technologies will be presented in interim reports. The technologies identified in this plan for pilot testing will be reviewed again later in annual reports. This review will include an evaluation of additional information on site contamination, Applicable or Relevant and Appropriate Requirements (ARARs), technology data, relative costs of conducting the pilot tests and of implementing the technology at full scale, and input from the CDH and EPA. The need for pilot testing of the technologies which have been tested at the bench or laboratory scale will also be evaluated in the annual reports.

Five water treatment technologies were selected for bench or laboratory scale testing at this time. Ion exchange, oxidation/reduction, and adsorption were selected for treatability testing for treatment of both metals and radionuclides in surface water or groundwater. TRU/Clear™ and ultrafiltration/microfiltration were selected for treatability testing for treatment of radionuclides alone in surface water or groundwater. There were no semivolatile organic compounds identified as exceeding ARARs for surface water or groundwater in two or more OUs so no technologies applicable to treatment of these compounds were selected. No technologies applicable to treatment of volatile organic compounds or inorganics were selected for testing at the bench/laboratory scale as they have been demonstrated at that scale. However, ozonation, peroxide oxidation, ultraviolet oxidation, and ultraviolet photolysis technologies which are applicable to treatment of volatile organic compounds in water were identified for pilot testing.

Eight soil/sediment treatment technologies were selected for bench or laboratory scale testing at this time. Physical separation, soil washing, and the stabilization/fixation technologies, epoxy polymerization, polyester polymerization, and portland cement were selected for bench/laboratory treatability testing for treatment of metals and radionuclides in soils or sediments. TRU Clean™, magnetic separation, and fixation/stabilization with masonry cement were selected for bench/laboratory treatability testing for treatment of radionuclides in soil or sediments. There were no volatile organic compounds, semivolatile organic compounds, or inorganics identified as exceeding ARARs for soils or sediments in two or more OUs, so no technologies applicable to treatment of these compounds were selected. No technologies applicable to treatment of these contaminants were selected for inclusion in the site-wide treatability test program at this time. Other technologies for which the lab/bench tests are favorable may be considered for pilot-scale testing.

Innovative and emerging technologies will be examined for inclusion in the sitewide treatability program in annual reports. The same selection process will be used as was used in this report. The annual reports will include new information, as available, for the innovative and emerging technologies that have been considered in this report. The annual reports will reevaluate these technologies for possible future inclusion in the sitewide Treatability Studies Program.

Section 6.0 presents procedures for the preparation of future treatability study work plans. These guidelines, along with the treatability studies statements of work included in Appendix C, will provide the basis for preparing the detailed treatability study work plan for each of the selected technologies.

Upon satisfying National Environmental Policy Act (NEPA) requirements, the actual treatability studies will be performed. The results of the treatability tests will be presented in interim reports. Annual Reports will include the work performed to date and a review of new site characterization data, ARARs, and technology screening to identify any additional treatability testing required.

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. ATOMIC ENERGY COMMISSION
ARARs	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AWQC	AMBIENT WATER QUALITY CRITERIA
BDAT	BEST DEMONSTRATED AVAILABLE TECHNOLOGY
CDH	COLORADO DEPARTMENT OF HEALTH
CEARP	COMPREHENSIVE ENVIRONMENTAL ASSESSMENT & RESPONSE PROGRAM
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980
CFR	CODE OF FEDERAL REGULATIONS
CMS/FS	CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY
CWA	CLEAN WATER ACT
DOE	DEPARTMENT OF ENERGY
DOT	DEPARTMENT OF TRANSPORTATION
DQO	DATA QUALITY OBJECTIVE
DTPA	DIETHYLENETRIAMINEPENTAACETIC ACID
EDTA	ETHYLENEDIAMINETETRAACETIC ACID
EPA	U.S. ENVIRONMENTAL PROTECTION AGENCY
EM	ENVIRONMENTAL MANAGEMENT DEPARTMENT
ER	ENVIRONMENTAL RESTORATION
ERDA	ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FSP	FIELD SAMPLING PLAN
GAC	GRANULAR ACTIVATED CARBON
HEA	HUMAN HEALTH & ENVIRONMENTAL ASSESSMENT
HSL	HAZARDOUS SUBSTANCE LIST
HSP	HEALTH AND SAFETY PLAN
IAG	INTER-AGENCY AGREEMENT
IHSS	INDIVIDUAL HAZARDOUS SUBSTANCE SITES
IR	INFRARED RADIATION
ISV	IN-SITU VITRIFICATION
IWT	INTERNATIONAL WASTE TECHNOLOGIES
KPEG	POTASSIUM POLYETHYLENE GLYCOLATE
MCL	MAXIMUM CONTAMINANT LEVEL
MCLG	MAXIMUM CONTAMINANT LEVEL GOALS
NEPA	NATIONAL ENVIRONMENTAL POLICY ACT
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
NRC	NUCLEAR REGULATORY COMMISSION
O&M	OPERATIONS AND MAINTENANCE
OU	OPERABLE UNIT
OUR	OXYGEN UPTAKE RATE
PACT	POWDERED ACTIVATED CARBON TREATMENT
PCB	POLYCHLORINATED BIPHENYL
PCDD	POLYCHLORINATED DIBENZODIOXINS
PCE	TETRACHLOROETHYLENE
PNA	POLYNUCLEAR AROMATIC HYDROCARBONS
QAA	QUALITY ASSURANCE ADDENDUM
QAPP	QUALITY ASSURANCE PROGRAM PLAN
QAPjP	QUALITY ASSURANCE PROJECT PLAN

ACRONYMS AND ABBREVIATIONS
(Concluded)

QA/QC	QUALITY ASSURANCE/QUALITY CONTROL
RCRA	RESOURCE CONSERVATION AND RECOVERY ACT
RF	RADIO FREQUENCY
RFEDS	ROCKY FLATS ENVIRONMENTAL DATA SYSTEM
RFI	RCRA FACILITY INVESTIGATION
RFP	ROCKY FLATS PLANT
RI	REMEDIAL INVESTIGATION
RO	REVERSE OSMOSIS
ROD	RECORD OF DECISION
SARA	SUPERFUND AMENDMENTS & REAUTHORIZATION ACT
SDWA	SAFE DRINKING WATER ACT
SOP	STANDARD OPERATING PROCEDURE
SOW	STATEMENT OF WORK
SWMU	SOLID WASTE MANAGEMENT UNITS
TAL	TARGET ANALYTE LIST
TBC	TO-BE-CONSIDERED
TBP	TRIBUTYL PHOSPHATE
TCE	TRICHLOROETHYLENE
TCL	TARGET COMPOUND LIST
TCLP	TOXICITY CHARACTERISTICS LEACHING PROCEDURE
TDS	TOTAL DISSOLVED SOLIDS
TRU	TRANSURANIC
TS	TREATABILITY STUDY
TSP	TREATABILITY STUDIES PLAN
TSDF	TREATMENT, STORAGE, OR DISPOSAL FACILITY
UMTRA	URANIUM MILL TAILING REMEDIAL ACTION
USPS	UNITED STATES POSTAL SERVICE
UV	ULTRAVIOLET
VOC	VOLATILE ORGANIC COMPOUNDS
WQC	WATER QUALITY CRITERIA
WQCC	WATER QUALITY CONTROL COMMISSION

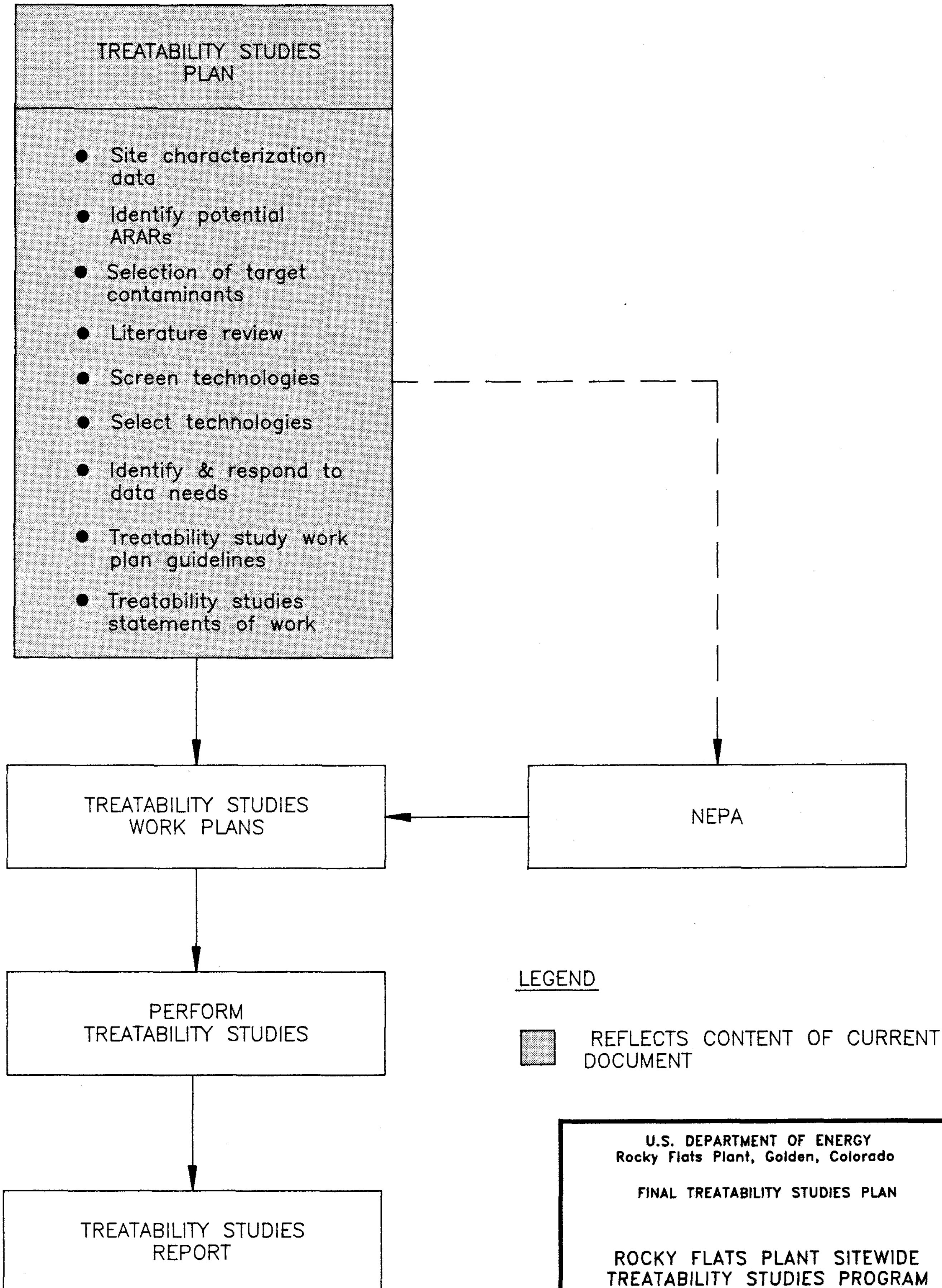
1.0
INTRODUCTION

The Treatability Studies Program as presented in this Treatability Studies Plan (TSP) is part of a comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress to address contamination associated with the Rocky Flats Plant. These activities are pursuant to the final Inter-Agency Agreement (IAG) developed among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH).

This document has been developed in accordance with Article XI of Attachment 2 of the Final IAG which states that DOE will develop a TSP to evaluate candidate remedial technologies for the general types of contamination encountered at the Rocky Flats Plant (RFP) (see Appendix E for copy of Article XI of IAG). National Environmental Policy Act (NEPA) documentation will be required on this project. Necessary NEPA documentation will be provided prior to any activity that requires it. This plan addresses the identification, evaluation, and selection of treatment technologies for remediation of contaminated media on a sitewide basis. The program is intended to provide information useful for conduction of CMS/FS efforts at individual OUs. The sitewide treatability study program is intended to address technologies applicable to remediation efforts at two or more OUs and is separate from any treatability study testing which may be conducted as part of remedial actions at individual OUs. Primary elements of the Treatability Studies Program are shown in Figure 1-1. Guidelines for preparing this TSP were derived from the documents shown in Table 1-1.

This document is divided into eight sections and three appendixes. Section 1.0 provides an introduction. Background information on the Rocky Flats Plant is presented in Section 2.0. A description of the Treatability Studies Program objectives is found in Section 3.0 and a description of the sitewide contamination is included as Section 4.0. Section 5.0 presents the technology selection process that was followed for completing the technology evaluations, as well as the technologies evaluation and selection summary. Section 6.0 provides guidelines for preparing the treatability study work plans for each of the technologies selected for inclusion in the sitewide treatability study program. Section 7.0 presents the deliverables and schedule for completing the program and Section 8.0 lists references used.

Appendices include Appendix A - Potential Applicable Relevant and Appropriate Requirements (ARARs) for the Sitewide Treatability Studies Program; Appendix B - Technology Data Sheets for Technologies which Passes Preliminary Screening; and Appendix C Treatability Studies Statements of Work; Appendix D - Inter-Agency Agreement Definition of Treatability Study Plan and Responses.



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ROCKY FLATS PLANT SITEWIDE
TREATABILITY STUDIES PROGRAM

FIGURE 1–1 **MAY 1991**

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The Rocky Flats Plant is a government-owned, contractor-operated facility which is part of the nationwide nuclear weapons production complex. The Plant was operated for the U.S. Atomic Energy Commission (AEC) from the Plant's inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for the Plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the DOE in 1977. Dow Chemical U.S.A., an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975. Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant from July 1, 1975 until December 31, 1989. EG&G Rocky Flats, Inc. became the prime contractor at the Rocky Flats Plant on January 1, 1990. Additional detail concerning the Plant operations, physical setting, and previous environmental investigations that have been conducted are included in the following subsections.

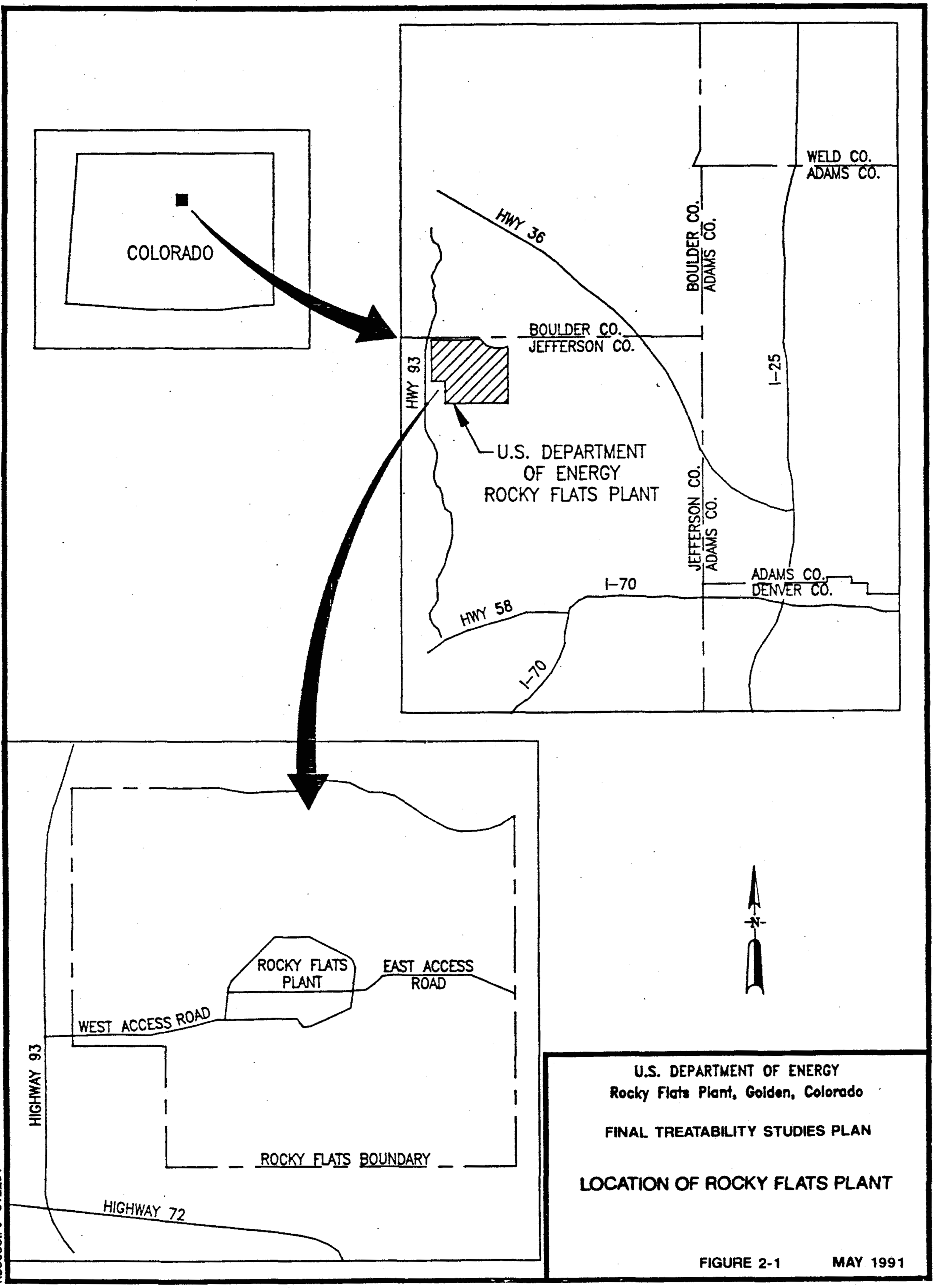
2.1 PLANT OPERATIONS

The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium, uranium, and nonradioactive metals (principally beryllium and stainless steel). Parts made at the Plant are shipped elsewhere for final assembly. The Plant reprocesses components for recovery of plutonium after they are removed from obsolete weapons. Other activities at the Rocky Flats Plant includes research and development in metallurgy, machining, nondestructive testing, chemistry, physics, engineering, and environmental management.

Both radioactive and nonradioactive wastes are generated in the production process. Current waste handling practices involve on-site and off-site recycling of hazardous materials, on-site storage of hazardous and radioactive mixed wastes, and off-site disposal of solid radioactive materials at another DOE facility. However, both storage and disposal of hazardous and radioactive wastes occurred on site in the past. Preliminary assessments under the ER Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

2.2 PHYSICAL SETTING

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 2-1). Other surrounding cities include Boulder, Westminster, and Arvada, which are located less than 10 miles to the northwest, east and southeast, respectively. The Plant consists of approximately 6,550 acres of federal land and occupies Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian. Major buildings are located within the Plant



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LOCATION OF ROCKY FLATS PLANT

FIGURE 2-1 MAY 1991

security area of approximately 400 acres. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 2-2).

The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains. The Plant is directly east of the north-south trending Rocky Mountains, with an elevation of approximately 6,000 feet above sea level. The Rocky Flats Plant is located on a broad, eastward sloping plain of overlapping alluvial fans developed along the Front Range. The fans extend about five miles in an eastward direction from their origin in the abruptly rising Front Range and terminate on the east at a break in slope to low rolling hills. The Continental Divide is about 16 miles west of the Plant. The operational area at the Plant is located near the eastern edge of the fans on a terrace between stream-cut valleys (North Walnut Creek and Woman Creek).

Three intermittent streams drain the Rocky Flats Plant with flow generally from west to east. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 2-2). Rock Creek drains the northwestern corner of the Plant and flows northeast through the buffer zone to its off-site confluence with Coal Creek. An east-west trending topographic divide bisects the Plant separating the Walnut and Woman Creek drainages. North and South Walnut Creeks and an unnamed tributary drain the northern portion of the Plant security area. These three forks of Walnut Creek join in the buffer zone and flow around Great Western Reservoir through a diversion ditch approximately one mile east of the confluence. Woman Creek drains the southern Rocky Flats Plant buffer zone flowing eastward to Standley Reservoir. The South Interceptor Ditch lies between the Plant and Woman Creek. The South Interceptor Ditch collects runoff from the southern Plant security area and diverts it to Pond C-2, where it is monitored in accordance with the Plant National Pollutant Discharge Elimination System (NPDES) permit prior to being pumped and discharged into Walnut Creek.

The area surrounding the Rocky Flats Plant has a semiarid climate characteristic of much of the central Rocky Mountain region. Approximately 40 percent of the 15-inch annual precipitation falls during the spring season, much of it as wet snow. Thunderstorms (June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (DOE, 1980). Studies of air flow and dispersion characteristics (e.g., Hodgin, 1983 and 1984) indicate that drainage flows, which are winds coming down off the mountains to the west, turn and move toward the north and northeast along the South Platte River valley and pass to the west and north of Brighton, CO (DOE, 1986).

2.3 REGIONAL AND LOCAL HYDROGEOLOGY

The stratigraphic section that pertains to Rocky Flats Plant includes, in descending order, unconsolidated surficial units (Rocky Flats Alluvium, various other alluvial deposits, valley fill alluvium, and colluvium), the Arapahoe Formation, the Laramie Formation, and Fox Hills Sandstone. Figure 2-3 presents a generalized stratigraphic section of the Denver Basin bedrock, and Figure 2-4 shows a generalized stratigraphic section of the Rocky Flats Plant, including unconsolidated deposits. Figure 2-5 depicts the erosional surfaces of alluvial deposits east of the Front Range, Colorado. Groundwater occurs under unconfined conditions in both the surficial and shallow bedrock units. In addition, confined groundwater flow occurs in deeper bedrock sandstones (e.g., Fox Hills Sandstone).

Rocky Flats Alluvium

The Rocky Flats Alluvium underlies a large portion of the Plant. The alluvium is a broad deposit consisting of a topsoil layer underlain by up to 100 feet of varying amounts of silt, clay, sand, and gravel. Unconfined groundwater flow occurs in the Rocky Flats Alluvium, which is relatively permeable. Recharge to the alluvium is from precipitation, snowmelt, and water losses from ditches, streams, and ponds that are cut into the alluvium. General water movement in the Rocky Flats Alluvium is from west to east and toward the drainages. Groundwater flow is also controlled by pediment drainages in the top of bedrock. Groundwater levels in the Rocky Flats Alluvium rise in response to recharge during the spring and decline during the remainder of the year. Discharge from the alluvium occurs at seeps in the colluvium that covers the contact between the alluvium and bedrock along the edges of the valleys. Most seeps flow intermittently. The Rocky Flats Alluvium thins and discontinues east of the Plant boundary. It does not directly supply water to wells located downgradient of the Rocky Flats Plant.

Other Alluvial Deposits

Various other alluvial deposits occur topographically below and east of the Rocky Flats Alluvium in the Plant drainages. Colluvium (slope wash) mantles the valley side slopes between the Rocky Flats Alluvium and the valley bottoms. In addition, remnants of younger terrace deposits, including the Verdos, Slocum, and Louviers alluvial deposits, occur occasionally along the valley side slopes. Recent valley fill alluvium occurs in the active stream channels.

Unconfined groundwater flow occurs in these surficial deposits. Recharge occurs through precipitation, infiltration from streams during periods of surface water runoff, and by seeps discharging from the Rocky Flats Alluvium. Discharge occurs through evapotranspiration and by seepage into other geologic formations, subcrops, and streams. The direction of groundwater flow is generally easterly and downslope through colluvial materials and then along the course of the stream in valley fill materials.

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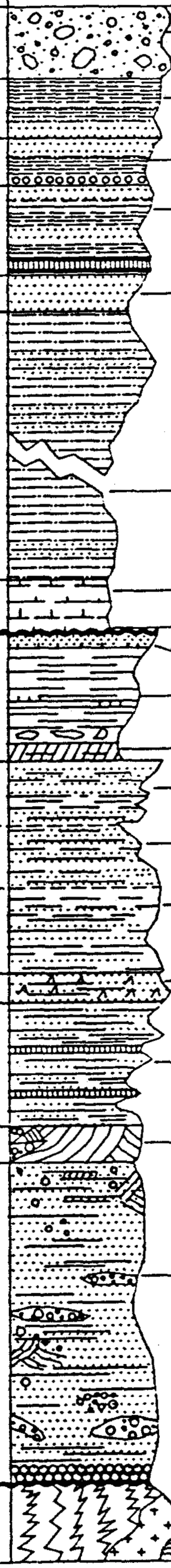

AGE	FORMATION	Thickness (feet)	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600'	Boulder conglomerate with occasional thin siltstone lenses
TERTIARY	Denver	870'	Yellowish-brown to grayish-olive fluvial tuffaceous claystone, siltstone, and sandstone interbedded with conglomerate and olive-gray mudflows
UPPER CRETACEOUS	Arapahoe	270'	Yellowish-gray to yellowish-brown sandstone; siltstone; and claystone; discontinuous conglomerate at base
UPPER CRETACEOUS	Laramie	500'	Gray, fine-to-medium-grained sandstone and silty clays; thin coal beds in lower part
UPPER CRETACEOUS	Fox Hills	60'	Tan, fine-to-medium-grained sandstone and sandy shale
UPPER CRETACEOUS	Pierre	± 8000'	Dark gray, silty shale and few thin, silty sandstones
UPPER CRETACEOUS	Niobrara	350'	Dark gray, very calcareous shale. "Foraminifers" abundant (Smoky Hills Member) Light gray, dense, fossiliferous limestone (Fort Hays Member)
UPPER CRETACEOUS	Benton	420'	Brown, sandy, fossiliferous limestone Dark gray shale with bentonite streaks; thin limestones in middle part; few cone-in-cone concretions in lower part Dark gray, brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group: So. Platte	270'	Light gray, fine-to-medium-grained sandstone, several dark gray shales in middle part
LOWER CRETACEOUS	Dakota Group: Lytle	100'	Light gray, fine-to-coarse-grained, locally conglomeratic sandstone; frequent red and green siltstone interbeds
Jurassic	Morrison	365'	Gray to greenish-gray to red shale and siltstone; thin limestones in middle part; lenticular sandstones in upper and lower part
Jurassic	Ralston Creek	110'	Light tan siltstone and light red; silty shale; gypsiferous; sandstone at base and locally conglomeratic
TRI-ASSIC?	Lykins	400'	Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120'	Grayish-white, fine-to-medium-grained cross-bedded sandstone; conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000'	Red, fine-to-coarse-grained sandstone and conglomerate; arkosic; thin, lenticular red siltstones frequent throughout
PRECAMBRIAN			Gneiss, schist, and small granite intrusions

(modified from: Weimer, 1973)

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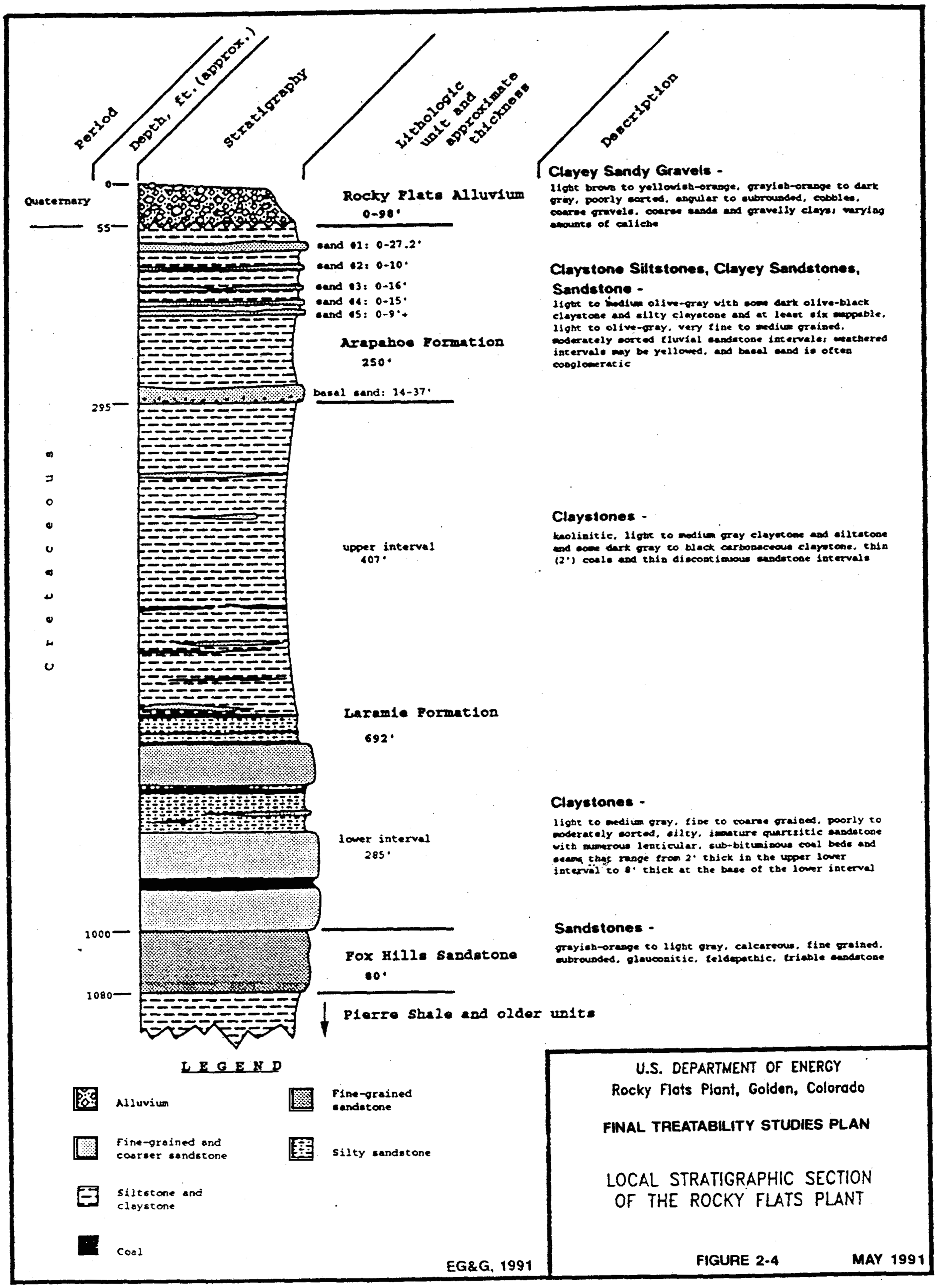
GENERALIZED STRATIGRAPHIC SECTION OF THE DENVER BASIN BEDROCK

FIGURE 2-3 MAY 1991



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LOCAL STRATIGRAPHIC SECTION OF THE ROCKY FLATS PLANT

FIGURE 2-4 MAY 1991

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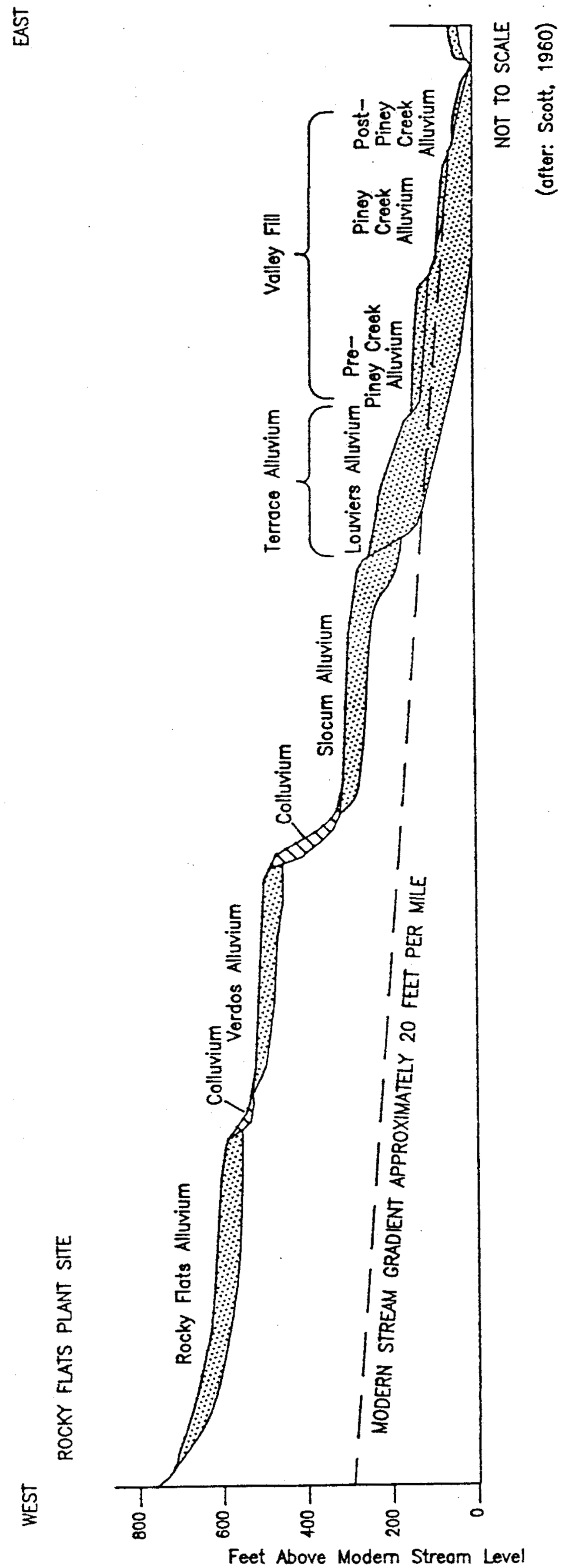

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EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE, COLORADO

FIGURE 2-5 MAY 1991

During the relatively short periods of high surface water flow that periodically occur, some water is lost to bank storage in the valley fill alluvium and then returns to the stream after the runoff subsides.

Arapahoe Formation

The Arapahoe Formation underlies surficial materials beneath the Plant. This formation is a fluvial deposit composed of overbank and channel deposits. It consists primarily of siltstones and claystones, with some silty sandstones beneath the Plant. Geologic characterization of the Arapahoe Formation beneath Rocky Flats indicates sandstones occur in stream channel-shaped structures. Total formation thickness varies up to a maximum of 270 feet (Robson et al. 1981a), and the unit is nearly horizontal beneath the Plant (less than two degree dip) (EG&G 1990a and 1990e). The channel sandstones within the claystone are composed of predominantly fine-grained sands and silts, and their hydraulic conductivity is equivalent to or less than that of the overlying Rocky Flats Alluvium. The Arapahoe Formation described by the earlier RFI/RI studies contains more clay and silt than typically described for other areas within the Denver Basin. There is a remarkable similarity of the siltstones and claystones beneath Rocky Flats to those of the Laramie Formation.

The Arapahoe Formation is recharged by groundwater from overlying surficial deposits and infiltration from streams. The main recharge areas are under the Rocky Flats Alluvium, although limited recharge from the colluvium and valley fill alluvium likely occurs along the stream valleys. Recharge is greatest during the spring and early summer, when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium are high. Groundwater movement in the Arapahoe Formation is generally toward the east, although the groundwater flow regime in the bedrock has generally not yet been characterized. Regionally, groundwater flow in the Arapahoe formation is toward the South Platte River in the center of the Denver Basin (Robson et al. 1981a).

Laramie Formation and Fox Hills Sandstone

The Laramie Formation underlies the Arapahoe Formation and is composed of two units: a thick upper claystone and a lower sandstone. The claystone is greater than 700 feet thick and is of very low hydraulic conductivity; therefore, the U.S. Geologic Survey (Hurr 1976) concluded that Plant operations will not impact any units below the upper claystone unit of the Laramie Formation.

The lower unit of the Laramie Formation and the underlying Fox Hills Sandstone form a regionally important aquifer in the Denver Basin known as the Laramie-Fox Hills Aquifer. Near the center of the basin, the aquifer thickness ranges from 200 to 300 feet. These units subcrop west of the Plant and can be seen in clay pits excavated through the Rocky Flats Alluvium. The steeply dipping beds of these units west of the Plant (approximately a 50° dip) quickly flatten to the east (less than 2° dip) (EG&G

1990a, and 1990e). Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and infiltration along the Front Range (Robson et al. 1981b).

2.4 PREVIOUS INVESTIGATIONS

Various studies have been conducted at the Rocky Flats facility to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment.

In 1986, two major investigations were completed at the Plant. The first was the ER Program Phase 1 installation assessment (DOE, 1986) which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. A number of sites were identified that could potentially have adverse impacts on the environment. These sites were designated as Solid Waste Management Units (SWMUs) (Rockwell International, 1987) and were divided into three categories:

- Hazardous waste management units that will continue to operate and need a RCRA operating permit.
- Hazardous waste management units that will be closed under RCRA interim status.
- Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA. No RCRA or CERCLA regulatory distinction in the use of the terms "site," "unit," or "SWMU" is intended in this document. The IAG (January 1991) designated all SWMUs to be Individual Hazardous Substance Sites (IHSS). These two terms are used interchangeably in this document.

The second major investigation completed at the Plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire Plant site. Plans for this study were presented in Rockwell International (1986a and 1986b), and study results were reported in Rockwell International (1986c). Investigation results indicated four areas as significant contributors to environmental contamination, with each area containing several sites. The areas are the 881 Hillside Area, the 903 Pad Area, the Mound Area, and the East Trenches Area. Site characterization work has continued since 1986 at several Operable Units (OUs). However, it is not within the scope of this plan to incorporate those results.

3.0
PROGRAM GOALS AND OBJECTIVES

The overall objective of the Treatability Studies Program, as presented in this Treatability Studies Plan (TSP), is to provide treatability studies information to support the Corrective Measure Studies or Feasibility Studies (CMS/FSs) that will be conducted at each of the 16 Operable Units (OUs). The program will shorten the overall time required to complete these studies by identifying technologies which are potentially applicable for remediating the types of wastes and waste matrices that may be common to more than one OU. Conducting treatability studies on these technologies as part of the Treatability Studies Program will generate the data required to evaluate and screen technologies and/or alternatives. The program will be implemented separately from the CMS/FSs, and will not replace the extensive identification and screening of technologies that will be conducted by the CMS/FS at each OU. This program may not completely eliminate the need for treatability studies to be conducted during the individual CMS/FSs. The program may reduce the need for these additional treatability studies by (1) eliminating duplicate studies, and (2) producing a useful database to the CMS/FSs that require the data. Thus, the TSP may expedite the screening of technologies and alternatives for OUs whose treatability studies occur late enough to benefit from the sitewide Treatability Studies Program. Figure 3-1 shows the timing of the Treatability Studies Program relative to the timing of the individual OU CMS/FSs.

Protocols for conducting treatability studies as part of the Treatability Studies Program or the individual CMS/FSs are required to ensure that the data collected are accurate, complete, and appropriate. The development of these guidelines and any additional requirements is an objective of the program. These guidelines will be used in preparing a Treatability Study Work Plan for each treatability study. Each Treatability Study Work Plan will be based on the protocols presented in this document and will provide the test objectives and protocols specific to the technology to be evaluated. Data generated from treatability testing for individual OUs will be considered in preparation of the work plans. This data may lead to modification of the scope of tests for technologies which have been tested at individual OUs. The tests could be either expanded or eliminated as described in Section 6.1 of this TSP. Likewise, information developed in the sitewide Treatability Studies Program will be considered in the preparation of OU-specific Treatability Study Work Plans. For those technologies which will be tested in the sitewide program prior to an OU program for the same contaminant, sitewide study results will be evaluated, and the OU testing may be modified or eliminated as a result.

The investigations of the types and extent of contamination at each OU are being conducted under the Environmental Restoration (ER) Program by numerous CERCLA Remedial Investigations (RIs)/RCRA Facility Investigations (RFIs). The data collected by these studies may not provide all the information

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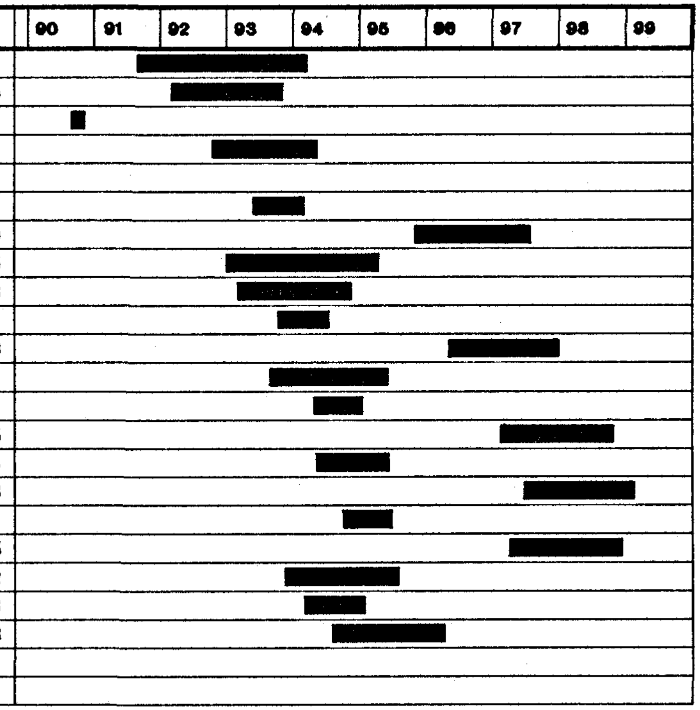
Activity Name	Description	Dur
SITEWIDE TS	SITEWIDE TREATABILITY STUDIES	791
OU1-FS	OU1 - FEASIBILITY STUDY	435
OU2-TS	OU2 - TREATMENT STUDY (IM/IRA)	61
OU2-FS	OU2 - FEASIBILITY STUDY	417
OU3	OU3 - INFORMATION NOT AVAILABLE	0
OU4-TS	OU4 - TREATMENT STUDY (IM/IRA)	190
OU4-FS	OU4 - FEASIBILITY STUDY	439
OU5-FS	OU5 - FEASIBILITY STUDY	585
OU6-FS	OU6 - FEASIBILITY STUDY	436
OU7-TS	OU7 - TREATMENT STUDY (IM/IRA)	191
OU7-FS	OU7 - FEASIBILITY STUDY	436
OU8-FS	OU8 - FEASIBILITY STUDY	441
OU9-TS	OU9 - TREATMENT STUDY (IM/IRA)	191
OU9-FS	OU9 - FEASIBILITY STUDY	435
OU10-TS	OU10 - TREATMENT STUDY (IM/IRA)	278
OU10-FS	OU10 - FEASIBILITY STUDY	453
OU11-TS	OU11 - TREATMENT STUDY (IM/IRA)	196
OU11-FS	OU11 - FEASIBILITY STUDY	435
OU12-FS	OU12 - FEASIBILITY STUDY	442
OU13-FS	OU13 - FEASIBILITY STUDY	223
OU14-FS	OU14 - FEASIBILITY STUDY	443
OU15	OU15 - INFORMATION NOT AVAILABLE	0
OU16	OU16 - INFORMATION NOT AVAILABLE	0



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY STUDIES PLAN

SITEWIDE / INDIVIDUAL OPERABLE UNIT TREATABILITY STUDIES SCHEDULE

FIGURE 3-1 MAY 1991

required to evaluate and screen technologies during the CMS/FSs or to support the conduct of treatability studies. Where specific field or quality assurance activities are required for development ofa site- or activity-specific treatability study work plan, a Field Sampling Plan (FSP) and Quality Assurance Addenda (QAA) will be developed. The FSP will define field sampling objectives and procedures and will be in accordance with the ER Program Standard Operating Procedures (SOPs). The QAAs will be in the format presented in the Quality Assurance Project Plan (QAPjP), but will not restate applicable sitewide requirements. The QAPjP will not be modified to meet the needs of each treatability study.

The specific goals of this program are to:

- Identify, evaluate, and select candidate technologies for treatability testing based on sitewide contamination data.

- Provide the protocols for preparing both the Sitewide and OU-Specific Treatability Study Work Plans and for conducting treatability studies.

- Review and modify, as required, the FSP and QAPjP.

- Prepare the executable level Treatability Study Work Plans for the Sitewide Program.

- Perform the treatability testing work and provide interim summary reports along with recommendations.

- Provide Treatability Study Annual Reports.

3.1 RELATIONSHIP OF THE TSP TO OU-SPECIFIC CMS/FSs

The technical approach and major elements of the TSP are presented in Section 5.0. Figure 3-2 shows the relationship of the TSP with the OU-Specific CMS/FSs.

The overall approach utilizes multiple tiers of testing to provide data to support evaluation of a specific remedy in an FS. The initial tier, which forms the basis of the sitewide TS, includes early pre-screening of technologies using available information. At this stage, however, there are significant data gaps regarding site characteristics. Many of the site characteristics and measurement parameters which are needed to recommend potential treatment technologies will not be available. Therefore, remedy screening studies are being designed so that they are relatively inexpensive and reasonably quick to perform. Evaluation of a number of technologies at the screening level will provide a more scientifically supported selection of treatment technologies on which to conduct detailed testing.

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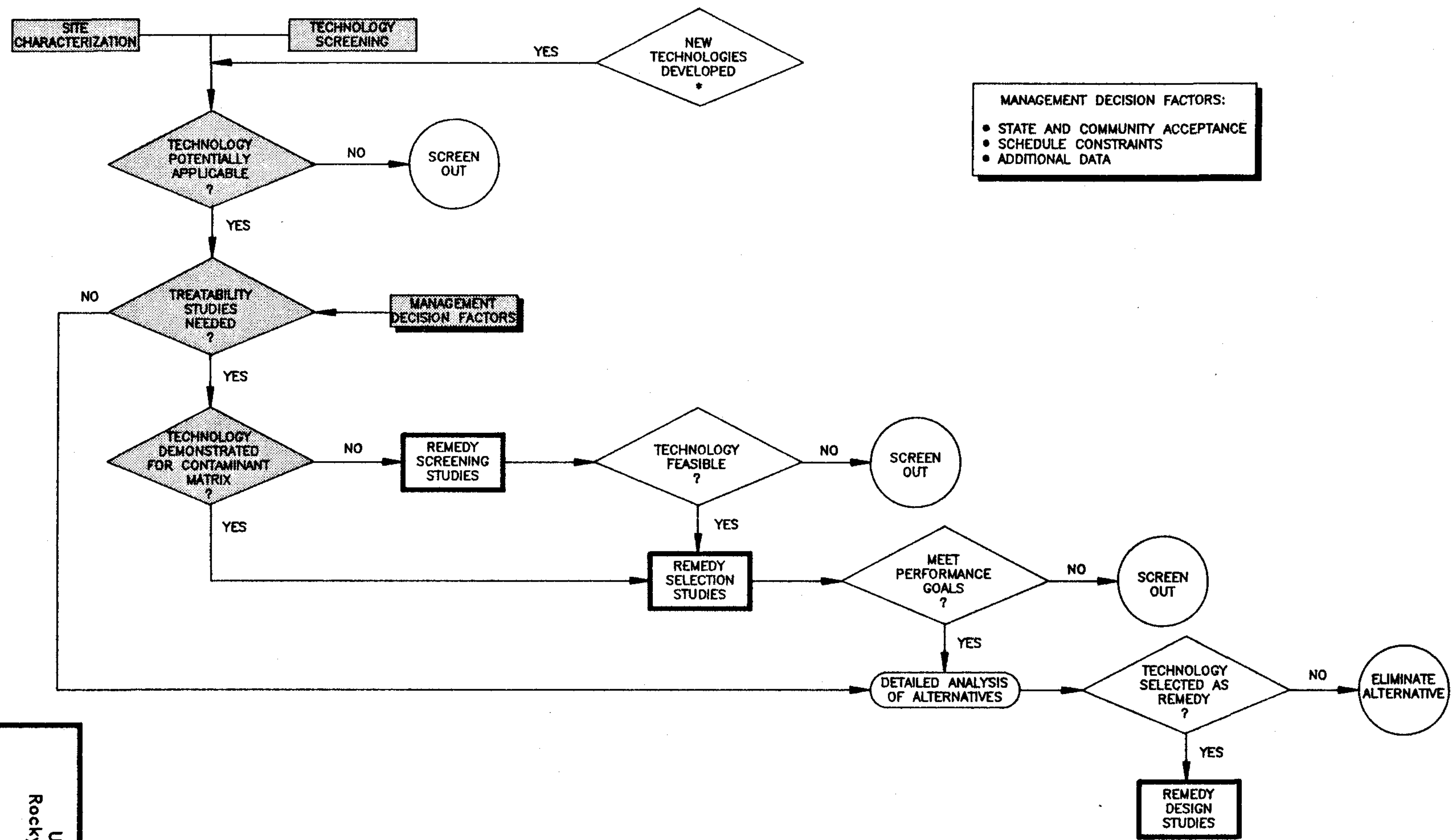


INCLUDED IN SITEWIDE TREATABILITY STUDIES PLAN (ALSO INCLUDED IN SPECIFIC OU PROGRAMS)

OU-SPECIFIC CMS/FS

SOURCE: EPA/600/9-91/002

* During the period from this TSP finalization to completion of currently selected technologies

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY STUDIES PLAN

RELATIONSHIP OF THE TSP TO OU-SPECIFIC CMS/FSs

FIGURE 3-2 MAY 1991

When conducting screening treatability tests there is also a greater risk of both 'false positives' (deciding to conduct further testing on an inappropriate technology) and 'false negatives' (deciding that a technology is not appropriate for a site when in fact it is appropriate). By conducting a number ofrelatively inexpensive screening tests for a specific site, these risks of inappropriate decisions regarding treatment technologies at the screening level are acceptable when balanced against the savings of time and money. It is very possible that new technologies will become available after the TSP is finalized and prior to completion of the treatability studies. These new technologies will be screened and added to the sitewide testing program, if appropriate.

The results of the sitewide treatability studies, together with similar OU-specific treatability studies, and additional OU site characterization data may indicate that a treatment technology should proceed to remedy selection treatability testing.

The remedy selection tier of testing, which will only be done at the specific OUs, is used to provide data to support evaluation of a specific remedy in the FS. The remedy selection treatability test should provide performance data which will indicate whether ARARs or cleanup goals can be met at the site by the technology. Remedy selection treatability tests should also allow for estimation of costs associated with implementation of the remedy to the accuracy required for the FS (+50/-30%). Remedy selection treatability testing requirements vary depending on the technology being evaluated and onsite specific factors. For some technologies, additional testing only at a laboratory bench scale may be sufficient to provide performance data adequate to meet the needs of the FS. In other cases, pilot scale testing may be required. Pilot scale testing will usually be necessary where it is difficult to simulate field conditions in the laboratory (e.g., in-situ treatment technologies). Where the types of experiments and equipment involved in remedy selection treatability tests are very specific to the treatment process, remedy selection testing will probably have to be conducted by the technology vendor. In other cases, the treatment process could be carried out by a number of vendors, and if the treatment equipment is more commonly available (e.g., some types of incineration), remedy selection treatability testing could be conducted by any suitably equipped facility.

In the event that no existing technologies are adequate to achieve possible or potential ARARs at a specific site (e.g., State Water Quality Standards for the terminal ponds), reasonable efforts will be used to develop and implement such technologies. Where additional technologies need to be developed or additional treatments are required, appropriate modifications to the Work Plan will be made, including schedules.

In summary, the primary purpose of the TSP is to expedite the screening of technologies and alternatives for the types of contaminants that appear to be generally present at the site. In parallel with the TSP, CMS/FSs for each of the individual OUs at the Rocky Flats Plant will be conducted. The TSP will provide information to demonstrate whether or not certain technologies should be considered further for specific problems in these OU-specific CMS/FSs.

As shown in Figure 3-2, the information obtained from the sitewide and specific OU treatability studies will provide data to support the final remedy selection and design process. In this figure, "Remedy Screening Studies" refers to the forthcoming treatability studies, which will be done on both a sitewide and OU specific level. "Remedy Selection Studies" refers to the final evaluation and selection of remediation technologies, which is only done at the OU specific level. However, due to project scheduling constraints, not all of the OU-specific CMS/FSs will benefit from the sitewide Treatability Studies Program; that is, some of the CMS/FS treatability studies will occur before the latter of the sitewide treatability studies are complete (see schedule in Figure 3-1).

In order to expedite the transfer of information gained during the sitewide Treatability Studies Program, interim and annual reports will be issued as appropriate. However, it is not intended that the sitewide program schedule will be adjusted to meet the needs of a specific OU.

3.2 RELATIONSHIP OF THE TSP TO OTHER TREATABILITY PROGRAMS AT RFP

RFP has the opportunity to participate in outside-sponsored/funded treatability related studies. The findings of any other related treatability work that will be done will be utilized in Treatability Studies Program reports. Two external programs in which RFP has expressed interest include DOE Headquarters Office of Technology Development (OTD) funded programs and the EPA Superfund Innovative Technology Evaluation (SITE) demonstrations. However, there are two primary issues concerning participation, funding and outside control (programs may be canceled at any time due to conditions outside the control of RFP). These issues make RFP participation questionable. Funding is external to DOE Environmental Restoration, and generally have no provision for funding EG&G staff or of other support costs. Because of the uncertainties about RFP participation, these programs are not included as part of the TSP. Nonetheless, we are including information on these other treatability programs as they may be pertinent to our treatability studies.

Once participation is decided, it is the intent of DOE to coordinate with EPA and CDH prior to conducting any treatability testing, including those tests conducted offsite.

<u>Office of Technology Development</u>

OTD is funding research and development, demonstration, testing, and evaluation activities in environmental restoration. Two environmental restoration-related treatability programs include:

- Integrated Demonstrations (IDs) with other DOE sites

  IDs are funded for several DOE sites to co-participate so that the study and outcome are applicable to the various sites participating. There are several treatability IDs being initiated or ongoing. RFP plans to participate in at least two. These include:

  Plutonium in Soils Cleanup Integrated Demonstration. The Plutonium in Soils Cleanup Integrated Demonstration is being hosted by the Nevada Test Site (NTS) with the purpose for evaluation of gravimetric separation (physical separation/soil washing) and other potential treatments for removal of plutonium/americium in soils. RFP intends to collect representative soil samples, and transport them to NTS for characterization and testing of the selected processes.

  Volatile Organic Compounds in Soil and Water (Arid Site) Integrated Demonstration (VOCID). The VOCID is being hosted by Hanford with the purpose of evaluating cleanup of plutonium/americium and carbon tetrachloride in the unsaturated/saturated zone at a location at Hanford. RFP intends to participate in this ID on a "program planning and review" level.

- Program Research and Development Announcement (PRDA).

  Plutonium/Americium Soil Cleanup at OU2. The PRDA is another OTD funded program. If this program goes forward, an announcement in the Commerce Business Daily will solicit proposals from private industry for consideration.

U.S. EPA Superfund Innovative Technology Evaluation (SITE) Program

The EPA SITE group is considering conducting a SITE field-scale demonstration at RFP.

- Techtran Demonstration Program. A demonstration is planned for the Techtran RHM 1000 process for removing radionuclides and heavy metal contaminated waste water. The Solar Pond (Operable Unit No. 4) seepage collection system water is proposed for collection and treatment with the Techtran process.

In case neither of the above programs will be in the stage of development (completed) for the sitewide treatability study annual report to incorporate the results and lessons learned during the testing from these programs, the sitewide treatability study program will develop necessary documentation and procedures to include these or similar technologies (in case they will pass screening) into the TSP.

Lessons and data obtained during the additional tests will be utilized in the treatability study report and recommendations will be made for the future development based on the findings and analytical data.

All the data received from the individual treatability tests related to technology(ies) development will be utilized, and future development, if required, will be performed after the screening and evaluation of the technology(ies). The same procedure will apply to any other DOE facilities tests and data made available from environmental restoration activities at RFP. These particular technologies will be handled by RFP according to regulations with the approval of EPA.

Results received from the various outside programs will be utilized to the extent practicable. Any results and lessons learned during these studies will be included in the annual Treatability Studies Program Annual reports.

3.3 INTERIM AND ANNUAL REPORTS

The Treatability Studies Program includes the preparation of interim and annual reports. Interim reports will be prepared when individual bench or pilot scale studies are completed and will present all results or conclusions. This will facilitate the provision of relevant information to individual OU programs as soon as possible.

Annual reports will provide information on the current status of the program and briefly summarize the interim reports. Any significant interim findings from the ongoing testing program will be included. Findings from other test programs in progress at Rocky Flats including OU-specific treatability studies will also be reviewed.

Annual reports will also include a review of additional site characterization data and any newly proposed ARARs and their impact on selected technologies. New technologies that become available during the reporting period will be screened through the same process presented in this TSP. Statements of work similar to those that appear in this TSP document will be provided in the Annual Reports for each technology which passes the screening and is selected for bench-scale or pilot studies. For each technology to be tested, work plans will be written in accordance with the guidelines in this TSP document. Technology evaluation-level studies will be conducted on these additional technologies only after agency review and comment on the annual report.

3.4 RELATIONSHIP OF THE TSP TO THE QUALITY ASSURANCE PLAN

A Site-wide Quality Assurance Project Plan (QAPjP) for the Rocky Flats Plant Environmental Restoration (ER) Program has been developed by the DOE and has been reviewed and approved by the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH). The scope of the QAPjP encompasses the environmental restoration activities, investigations, and studies required by the IAG, including this Treatability Studies Program.

The QAPjP addresses the quality assurance requirements and actions that are required by the DOE, EPA, and CDH. The QAPjP describes the ER Program's organization and responsibilities, the data quality objectives (DQOs) for the ER Program and the approach for developing site- and activity-specific DQOs, sampling and analytical procedures, sample handling and custody, data verification/validation, quality control checks, performance and system audits and surveillances, test controls, nonconformance reporting and corrective actions, and quality assurance reports to management. Quality Assurance Addenda to the QAPjP are developed to address the site- and/or activity-specific quality assurance requirements, objectives, and controls that are not addressed by the QAPjP because of its broad scope. QAAs will be developed for each of the future treatability studies that are developed to implement the program described in this TSP. See Section 6.12 for a discussion on amendments of Quality Assurance Plans.

3.5 RELATIONSHIP OF TREATABILITY STUDY TO THE SPECIFIC FIELD SAMPLING PLAN

The Field Sampling Plan (FSP) will be prepared as an attachment to the individual treatability study work plan for each technology selected for testing (bench scale and pilot scale). Health and safety procedures which have to be followed during the field sampling will be incorporated in the FSP.

All the information provided in the FSP will be in accordance with the environmental restoration Standard Operating Procedures.

The FSP is discussed in Section 6.11.

4.0
SITE CONTAMINATION

Summaries of the potentially hazardous substances found within groundwater, surface water, soils, and wastes at the Rocky Flats Plant are presented in Section 4.0. This account is not intended to be exhaustive as numerous investigations are currently ongoing or planned for the future, but it does identify the major compounds of concern from a human health and environmental standpoint. Attempts have been made to represent the data from the source documents as accurately as possible. The documents which comprise the source of the historic data and current database used in this report are shown in Table 4-1. The current database chosen for use in this report is considered adequate for the purpose of selecting and screening of the practical technologies that should be considered on a sitewide basis. Section 5.0 provides additional discussion on the available data and its adequacy for the Treatability Studies Plan.

For the purpose of developing appropriate remedial actions, the 178 Individual Hazardous Substance Sites (IHSS) at the RFP were combined into 16 Operable Units (OUs). Specific or historic data on concentrations of contaminants at sites within a given OU are currently only available for OU1-8, OU10-14, and OU16. No data are presently available for OU9 or OU15. These data are summarized by OU in Section 4.1. A summary of the maximum and minimum analyte concentrations detected sitewide in the groundwater, surface water, soils, and sediments at these OUs as a group is presented in Section 4.3.

4.1 SUMMARY OF CONTAMINANTS - OPERABLE UNITS

A brief description of each OU and the potential contamination problems contained within these OUs is presented below. These OU descriptions are based on both the historic data and the current database (Table 4-1). Contaminants described as "above potential ARARs or screening criteria" are compared to the potential Applicable or Relevant and Appropriate Requirements presented in Table 4-2 or, where ARARs do not exist, to human health and environmental risk based screening criteria as presented in Table 4-2. The process followed in selecting possible or potential ARARs and comparing these ARARs to maximum values of contaminants reported at the site is described in Sections 4.2 and 4.3. Note that analytical data received prior to 1988 were not subject to validation procedures. Some of the contaminant values reported below and in Table 4-2 have not yet been validated, and the analyte list may be changed after the data are validated.

Operable Unit 1 - 881 Hillside

The 881 Hillside area is located in the southeast corner of RFP and consists of 11 hazardous substance sites. Volatile organic compounds (VOCs) reported above potential ARARs or screening criteria in the groundwater include 1,1-dichloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,2-dichloroethene (total), benzene, carbon tetrachloride, methylene chloride, tetrachloroethene, and trichloroethene.

Gross alpha activity has been reported above potential ARARs or screening criteria in groundwater at OU1. Metals reported above potential ARARs or screening criteria include antimony, chromium, cobalt, iron, manganese, nickel, selenium, and silver. Concentrations above potential ARARs or screening criteria of chloride, cyanide, nitrate or nitrate + nitrite, sulfate and total dissolved solids (TDS) have been reported in groundwater.

VOCs reported above potential ARARs or screening criteria in OU1 surface water are methylene chloride and tetrachloroethene. Concentrations above potential ARARs or screening criteria of aluminum, barium, beryllium, cadmium, chromium, iron, lead, manganese, mercury, selenium, and TDS have been reported for surface water. Values of pH both above maximum and below minimum standards (ARARs) have been reported in OU1 surface water. Gross alpha and gross beta activity, radium 226, radium 228, tritium, and total uranium have been reported above potential ARARs or screening criteria in surface water.

In OU1 soils, concentrations above potential ARARs or screening criteria of beryllium, gross alpha activity, and plutonium 239 + 240 have been reported. Levels above potential ARARs or screening criteria of beryllium and gross alpha activity have been reported in OU1 sediments.

Wastes spilled or disposed of within OU1 hazardous substance sites have included asbestos, fuel oil, waste oil, solvents, scrap metal, empty drums, and plutonium-contaminated soil and asphalt.

Operable Unit 2 - 903 Pad, Mound Area, and East Trenches

OU2 consists of 20 hazardous substance sites, including the 903 Pad, Mound Area, and East Trenches. The 903 Pad is located in the southeast corner of the RFP adjacent to 881 Hillside. The Mound Area is north of Central Avenue and west of the East Guard Gate, and the East Trenches are east of the 903 Pad. Other individual hazardous substance sites (IHSSs) are located in the vicinity of the 903 Pad and Mound Area. Wastes that were disposed of in OU2 include depleted uranium, plutonium chips, lathe coolant, uranium, americium, and plutonium-contaminated sewage sludge, asphalt, drums, and metal chips. Several of these disposal sites have been remediated. Solvents and other chemicals were also disposed of, or spilled, in this area.

Inorganic compounds, VOCs, and radionuclides have been reported above potential ARARs or screening criteria in groundwater at OU2. Inorganics, including levels of nitrate + nitrite, sulfate, and TDS above potential ARARs or screening criteria, along with pH values below the minimum standard (ARAR), have been reported in OU2 groundwater. VOCs reported at elevated concentrations are 1,1-dichloroethene, 1,1,1-trichloroethene, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,2-dichloroethene (total), carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, trichloroethene, and vinyl chloride. The semivolatile compounds bis-2(ethylhexyl) phthalate and di-n-butyl phthalate have been reported above potential ARARs or screening criteria in OU2 groundwater. Levels above potential ARARs or screening criteria of gross alpha activity have been reported in groundwater, along with concentrations above potential ARARs or screening criteria of antimony, arsenic, chromium, iron, lead, manganese, mercury, nickel, and selenium.

In OU2 surface water or seeps, VOCs reported above potential ARARs or screening criteria include carbon tetrachloride, methylene chloride, tetrachloroethene, and trichloroethene. Levels above potential ARARs or screening criteria of the inorganics nitrate + nitrite, plus pH values below the minimum standard, also have been reported in OU2 surface water. Radionuclides reported above potential ARARs or screening criteria in surface water at OU2 are gross alpha and gross beta activity, plutonium 239 + 240, tritium and total uranium. Concentrations above potential ARARs or screening criteria of the metals aluminum, antimony, chromium, iron, lead, manganese, and selenium have been reported in OU2 surface water.

The radionuclides gross alpha activity and plutonium 239 + 240 have been reported above potential ARARs or screening criteria in OU2 soils, while beryllium and gross alpha activity have been reported above potential ARARs or screening criteria in OU2 sediments.

<u>Operable Unit 3 - Off-Site Areas</u>

OU3 consists of four hazardous substance sites which are off-site (generally lying east of Indiana Street and adjacent to RFP). These sites include land surface, Great Western Reservoir, Standley Reservoir, and Mower Reservoir. These sites are currently under investigation as part of the RFP agreements with the U.S. Environmental Protection Agency and the Colorado Department of Health. Plutonium and americium have been reported in soils and sediments in the off-site areas. Radionuclide analyses of Great Western Reservoir and Standley Reservoir have indicated that low levels of various radionuclides may be present in the bottom sediments. Two documents have recently been prepared under the Interagency Agreement. These documents are the Past Remedy Reports, which cover land surface, and Historical Information Summary and Preliminary Health Risk Assessment Report, which covers the three reservoirs. Both documents provide historical information summaries and preliminary assessments of health risk to the public. The preliminary health risk assessments from these documents indicate that the potential risk from radionuclides is less than EPA's action level risk range of 10^{-4} to 10^{-6}.

Operable Units 4, 7, 9, 10, 11, and 15 - RCRA Closure Units

The RCRA closure units consist of 31 IHSSs including the Solar Evaporation Pond (OU4), the Present Landfill (OU2), Original Process Waste Line (OU9), Other Outside Closures (OU10), West Spray Fields (OU11), and Inside Building Closures (OU15). The major units are OUs 4, 7 and 10. Wastes associated with the Solar Evaporation Ponds included sanitary sewage sludge, various metals, and trace VOCs. The Present Landfill contains various solid wastes generated at the RFP including: rags with freon and trichloroethene, oil filters, metal chips, mineral and asbestos dust, mercury vapor lamp bulbs, fire extinguisher chemicals, deionizer exchange resin column, paint filters, settling basin sludge, and photography lab solid wastes.

The Original Process Waste Lines transported various aqueous process wastes containing low-level radioactive materials, nitrates, caustics and acids. RFI/RI studies are scheduled for all the RCRA Closure sites, at which time additional data will be available to further support the RFP Sitewide Treatability Studies.

Although contaminants listed below have been reported in one or more of these sites, it should be emphasized that not every contaminant listed has been reported in every RCRA Closure unit listed. VOCs reported above potential ARARs or screening criteria in groundwater at one or more of these sites include 1,1-dichloroethene, carbon tetrachloride, tetrachloroethene, and trichloroethene. Metals reported above potential ARARs or screening criteria in groundwater include chromium, cobalt, iron, lead, manganese, nickel, and selenium. Concentrations above potential ARARs or screening criteria of chloride, nitrate or nitrate + nitrite, sulfate, and TDS were reported in groundwater; levels above potential ARARs or screening criteria of gross alpha and gross beta activity also were reported in groundwater at one or more of these sites.

VOCs reported above potential ARARs or screening criteria in surface water include 1,1-dichloroethene, benzene, carbon tetrachloride, methylene chloride, tetrachloroethene, and trichloroethene. Metals reported above potential ARARs or screening criteria in surface water are aluminum, antimony, arsenic, barium, beryllium, chromium, iron, lead, manganese, nickel, selenium, and zinc. The inorganics reported above potential ARARs or screening criteria in surface water at one or more of these sites include nitrate + nitrite, sulfate, and TDS, plus pH values both above the maximum and below the minimum standards (ARARs). Radionuclides reported above potential ARARs or screening criteria in surface water at one or more sites include gross alpha and gross beta activity, plutonium 239 + 240, strontium 90, tritium, and total uranium.

Elevated levels of beryllium have been reported in soils at one or more of these sites.

Operable Units 5 and 6 - Woman Creek and Walnut Creek Drainages

OU5 and OU6 consist of 32 hazardous waste sites located on or near Woman Creek and North and South Walnut Creek drainages. Included within these Operable Units are several detention ponds, a landfill, trenches, spray fields, surface disturbances, outfalls, and a drum storage area. Comprehensive chemical analyses of groundwater, surface water, and soil have not been completed. However, some data are available.

In groundwater sampled at these OU5 and/or OU6 sites, nitrate has been reported above potential ARARs or screening criteria. VOCs reported above potential ARARs or screening criteria in OU5 and/or OU6 groundwater include carbon tetrachloride and tetrachloroethene.

In OU5 and/or OU6 surface waters, VOCs reported above potential ARARs or screening criteria include 1,1-dichloroethene, trichloroethene, and vinyl chloride. Metals reported above potential ARARs or screening criteria aluminum, antimony, barium, beryllium, cadmium, iron, lead, manganese, nickel, and selenium. Sulfate and TDS have been reported above potential ARARs or screening criteria, along with pH values both above the maximum and below the minimum standard. Radionuclides reported above potential ARARs or screening criteria are gross alpha and gross beta activity, tritium, and total uranium.

Soils have been subject to spills consisting of acids, metals, nitric acid, fuel oil, organics, sanitary sewer sludge, sodium, solvents, sulfates, unspecified wastes, and radiochemical components.

Operable Unit 8 - 700 Area

OU8 consists of 38 IHSSs throughout the RFP. Many of the sites are associated with storage tanks while the remainder are leaks or spills. Wastes at these sites are associated with soils. Various substances which have leaked onto the soil at this OU include acids, algicides, bases, beryllium, carbon tetrachloride, chromates, caustics, fluorides, hydrocarbons, metals, nitrates, organics, solvents, unspecified wastes, and radiochemical constituents.

Operable Unit 12 - 400/800 Area

OU12 consists of 12 IHSSs in the southeast portion of the RFP. Several of the sites are surface ponds; however, most are leaks or spills. Waste that spilled or leaked onto the soil includes acids, algicides, chromates, resins, catalysts, and solvents.

Operable Unit 13 - 100 Area

OU13 consists of 15 sites in the eastern sections of the RFP. These sites are spills, leaks, waste destruction sites, and storage areas. Historical data indicate that acids, bases, oil, organics, soaps, solvents, radiochemical components, as well as hydrogen peroxide and sodium hydroxide have spilled onto the soil in this OU.

Operable Unit 14 - Radioactive Sites

OU14 consists of nine IHSSs which are located throughout the RFP. Data on waste types indicate that unspecified radiochemical components, plutonium, and VOCs have been spilled on or buried in the soils within this OU.

Operable Unit 16 - Low Priority Sites

OU16 consists of seven low priority IHSSs throughout the RFP which include spill, leak, and disposal areas. Relatively few waste components are associated with the soils in this OU. Reported wastes include 1,1,1-trichloroethane, antifreeze, nickel carbonyl, and oil.

Upper and Lower South Interceptor Ditches

Concentrations above potential ARARS or screening criteria of the metals aluminum, antimony, barium, cadmium, chromium, iron, lead, manganese, and selenium have been reported in surface waters of these ditches, along with levels of nitrate and TDS above potential ARARs or screening criteria and pH values above the maximum and below the minimum standard. Levels above potential ARARs or screening criteria of gross alpha and gross beta activity, radium 226, and total uranium have been reported. Volatiles reported above potential ARARs or screening criteria in surface waters of these ditches are methylene chloride and trichloroethene.

In soils of these ditches, plutonium 239 + 240 has been reported above potential ARARs or screening criteria, and beryllium has been reported above potential ARARs or screening criteria in sediments.

Waste Disposal

Limited information exists about actual wastes disposed at the Rocky Flats Plant site. Hazardous wastes have been disposed at various locations including, but not restricted to, the present landfill. Since the "waste" category is associated with specific sites within each OU and specific site characterization data for wastes are currently not available, treatment of materials classified as waste was not considered in this TSP, but will be considered later as data from the individual waste sites become available.

4.2 ARAR IDENTIFICATION

Applicable or Relevant and Appropriate Requirements (ARARs) are required to provide a basis for determination of preliminary contaminants of concern. The basis for ARARs is cited in Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), which requires that Fund-financed, enforcement, and federal facility remedial actions comply with applicable or relevant and appropriate federal laws or promulgated state laws, whichever are more stringent. For the purposes of identification and notification of promulgated state standards, the term "promulgated" means that the standards are of general applicability and are legally enforceable (NCP, 40 CFR 300.400(g)(4). Colorado Department of Health (CDH) Water Quality Control Commission (WQCC) groundwater standards are not included as promulgated but rather are to-be-considered (TBC) since they are not yet enforceable.

Possible or potential ARARs are considered in this treatability studies plan in accordance with Section 121(d) of CERCLA, as amended by the SARA. Of the three categories of ARARs, chemical-specific ARARs are the most appropriate in evaluating the effectiveness of a technology and the results of a treatability study. Since the purpose of the treatabilities study is to evaluate a technology's effectiveness at treating waste at the Rocky Flats Plant (RFP) site, and the location- and action-specific ARARs provide little information on how effectively technology treats waste, only chemical-specific ARARs were considered for use at this time. Action- and location-specific ARARs will be evaluated prior to full-scale implementation of a remedial alternative.

A summary of possible or potential sitewide chemical-specific ARARs identified for use by this practical technologies program is presented in Appendix A in Table A-1, Groundwater Quality Standards, Table A-2, Federal Surface Water Quality Standards, and Table A-3, State Surface Water Quality Standards. This summary of possible or potential ARARs for groundwater and surface water is based on chemicals suspected to be present at RFP and the following current federal and state health and environmental statutes and regulations:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) applied to both surface and groundwater.

- Clean Water Act (CWA) Water Quality Criteria (WQC) applied to surface water.

- RCRA Subpart F Groundwater Concentration Limits (40 CFR 264.94) - applied to groundwater.

- Colorado Department of Health (CDH) surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.0, amended February 15, 1990) - applied to surface water.

- CDH WQCC proposed statewide and classified groundwater area standards (5 CCR 1002-8, Section 3.11) - applied to groundwater as TBC.

These ARARs are considered preliminary and will be subject to change as new federal and state standards are imposed, and as additional information from the baseline risk assessment and site characterization investigations for each OU become available. The final ARARs determination for each OU will be completed as part of the RCRA Facility Investigation/Remedial Investigation - Corrective Measures Study/Feasibility Study (RFI/RI-CMS/FS) conducted for that specific OU. As part of this determination, the possible or potential ARARs shown in Appendix A and accompanying regulations will be screened to determine their jurisdictional requirements and applicability. If the requirements are not applicable, they will be further screened to determine whether they are relevant and appropriate to the particular site-specific conditions. Where ARARs do not exist for a particular chemical or where existing ARARs are not protective of human health or the environment, to-be-considered (TBC) criteria, guidances, proposed standards, and advisories will be evaluated for use. Standards identified as possible or potential ARARs, as well as TBC criteria, will be analyzed according to the procedures outlined in the Superfund Public Health Evaluation Manual (U.S. EPA 1986b), NCP, and CERCLA Compliance with Other Laws Manual (U.S. EPA 1988c). The possible or potential ARARs identified for use in this TSP may not correlate to any future ARARs selected for that specific OU.

In addition to the possible or potential ARARs shown in Appendix A, human health and environmental assessment (HEA) criteria or "action levels" developed by EPA for carcinogens and systemic toxicants in soil and water were considered as possible or potential ARARs in this TSP in conformance with RFI guidance (U.S. EPA, 1989a). HEA criteria are derived from EPA-established chronic (and in some cases acute) toxicity criteria for ingestion of soil and drinking water. HEA criteria are not based on promulgated standards nor do they necessarily represent clean-up levels that must be achieved; rather, they establish presumptive levels that may indicate the need for closer site-specific examination of contaminant levels during the RI. Where sludges from treated surface and groundwater are designated for off-site disposal, additional possible or potential chemical-specific ARARs would include the RCRA Land Disposal Restrictions in 40 CFR 268.

Possible or potential sitewide ARARs were selected from Appendix A for comparison to sitewide maximum and minimum analyte concentrations in Section 4.3. The ARARs selected for comparison include current MCLs for drinking water; Federal WQC; and Colorado statewide and stream-segment standards for surface water, groundwater, and radionuclides. EPA's HEA criteria for the ingestion of carcinogens and systemic toxicants in soil and water (U.S. EPA 1989a) were also selected for use in this TSP. Federal regulations not yet in effect (i.e., 1992 MCL standards and goals) and current TBC MCL goals were not selected as ARARs for use in this TSP.

As the RI proceeds, information will become available through the risk assessment process which will allow a determination of acceptable contaminant concentrations to ensure "protectiveness" of human health and the environment. Development of a preliminary list of possible or potential chemical-specific ARARs in the RI process will allow the establishment of a list of preliminary reduction goals in the early Feasibility Study (FS) process, which is essentially a tentative listing of contaminants together with initially anticipated cleanup concentration or risk levels for each medium. Preliminary remediation goals will serve to focus the development of alternatives on remedial technologies that can achieve the remediation goals, thereby limiting the number of alternatives to be considered in the detailed remedial alternative analysis, conducted later in the FS process. As more information becomes available during the RI, chemical-specific ARARs may become more refined as constituents are added or deleted. Once data collection is complete, revised chemical-specific ARAR selection may be proposed.

4.3 SUMMARY OF CONTAMINANTS SITEWIDE AND COMPARISON TO ARARs

Maximum and minimum analyte concentrations detected sitewide in each matrix (e.g., groundwater, surface water, soils, and sediments) are presented in Table 4-2 and summarized below. The maximum values in Table 4-2 include both recent and historic data, updated using the most recent data available (as of April 1991) from the source documents listed in Table 4-1. Maximum values may represent a one time measurement. The minimum value is assumed to be the detection limit, which is listed in Table 4-2 when available. Note that analytical data received prior to 1988 were not subject to validation procedures.

ARAR values were selected from Appendix A for comparison to maximum and minimum analyte levels in Table 4-2. MCLs were selected as the principal ARARs for both surface water and groundwater. The lowest state standard was used for groundwater where there was no MCL. The state agricultural value in Table A-1 was not considered in determining the lowest state standard. In cases where the state standard was below the current analytical detection limit, the detection limit was used as the default value. For surface water, the lowest federal WQC was used where there was no MCL, unless the WQC was below detection limit, in which case the detection limit was used. The lowest state standard was used for surface water where there was no MCL or AWQC, unless this value was below detection limit, in which case the detection limit was used. The lowest systemic or carcinogenic HEA criterion was used for surface water and groundwater for those chemicals which had no MCL, WQC, or state standard. Where HEA criteria were below the detection limit, the detection limit was used.

For possible or potential soil and sediment ARARs, the lowest HEA criterion (systemic or carcinogenic) was used. The detection limit was used as the default value where the lowest HEA criterion was below the detection limit. The possible or potential ARAR value for plutonium in soils and sediments was based on State of Colorado (1985) Rules and Regulations Pertaining to Radiation Control. The possible or potential ARARs for gross alpha and gross beta emissions in soils and sediments were based on DOE requirements.

Groundwater

During 1986, groundwater samples were analyzed for the Target Compound List (TCL) volatiles and semivolatiles, and for the Target Analyte List (TAL) metals as well as major ions and radionuclides. During subsequent years, testing was limited to those contaminants previously detected. Elevated levels (e.g., above ARARs) of inorganics, metals, volatile organics, and radionuclides have been detected at various IHSSs within a given OU.

As shown in Table 4-2, maximum values in groundwater exceeded ARARs for the inorganic chemicals chloride, cyanide, nitrate, nitrate + nitrite, and sulfate. In addition, pH values both higher and lower than ARARs for drinking water were recorded. Total dissolved solids (TDS) concentrations also exceeded ARARs in groundwater.

Metals exceeding ARARs in groundwater included antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc.

Maximum values reported in groundwater exceeded ARARs for the volatile compounds 1,1-dichloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,2-dichloroethene (total), benzene, carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, trichloroethene, and vinyl chloride, and for the semivolatile compound bis (2-ethylhexyl) phthalate.

The only radionuclide in groundwater exceeding ARARs was gross alpha activity.

Surface Water

Maximum values in surface water exceeded ARARs for the inorganic chemicals, chloride, cyanide, nitrate, nitrite, and sulfate. As in groundwater, pH values both higher and lower than ARARs were recorded for surface water. TDS concentrations also exceeded ARARs in surface water.

Metals exceeding ARARs in surface water included aluminum, arsenic, antimony, barium, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc.

In surface water, the volatile compounds exceeding ARARs included 1,1-dichloroethene, benzene, carbon tetrachloride, methylene chloride, tetrachloroethene, trichloroethene, and vinyl chloride.

As was the case for groundwater, gross alpha activity in surface water exceeded ARARs. Other radionuclides exceeding ARARs in surface water included americium 241, gross beta activity, plutonium 239+240, radium 226, radium 228, tritium, and uranium (total).

Soils and Sediments

Few chemicals were reported exceeding ARARs in soils or sediments. There are several reasons for this. First, the soils and sediments database is more limited than the database for waters. Second, few ARARs are available for soils and sediments, and numerical values of ARARs which do exist are relatively high. Thus, the only chemicals reported at concentrations exceeding ARARs were the metal beryllium and the radionuclides gross alpha activity, and plutonium 239+240.

Pesticides and PCBs

Potentially 34 sites have been tentatively identified to be contaminated with PCBs. Confirmation sampling for these sites is now in progress. Based on the results obtained from this confirmation data, technologies applicable to PCBs may be reviewed at a later date.

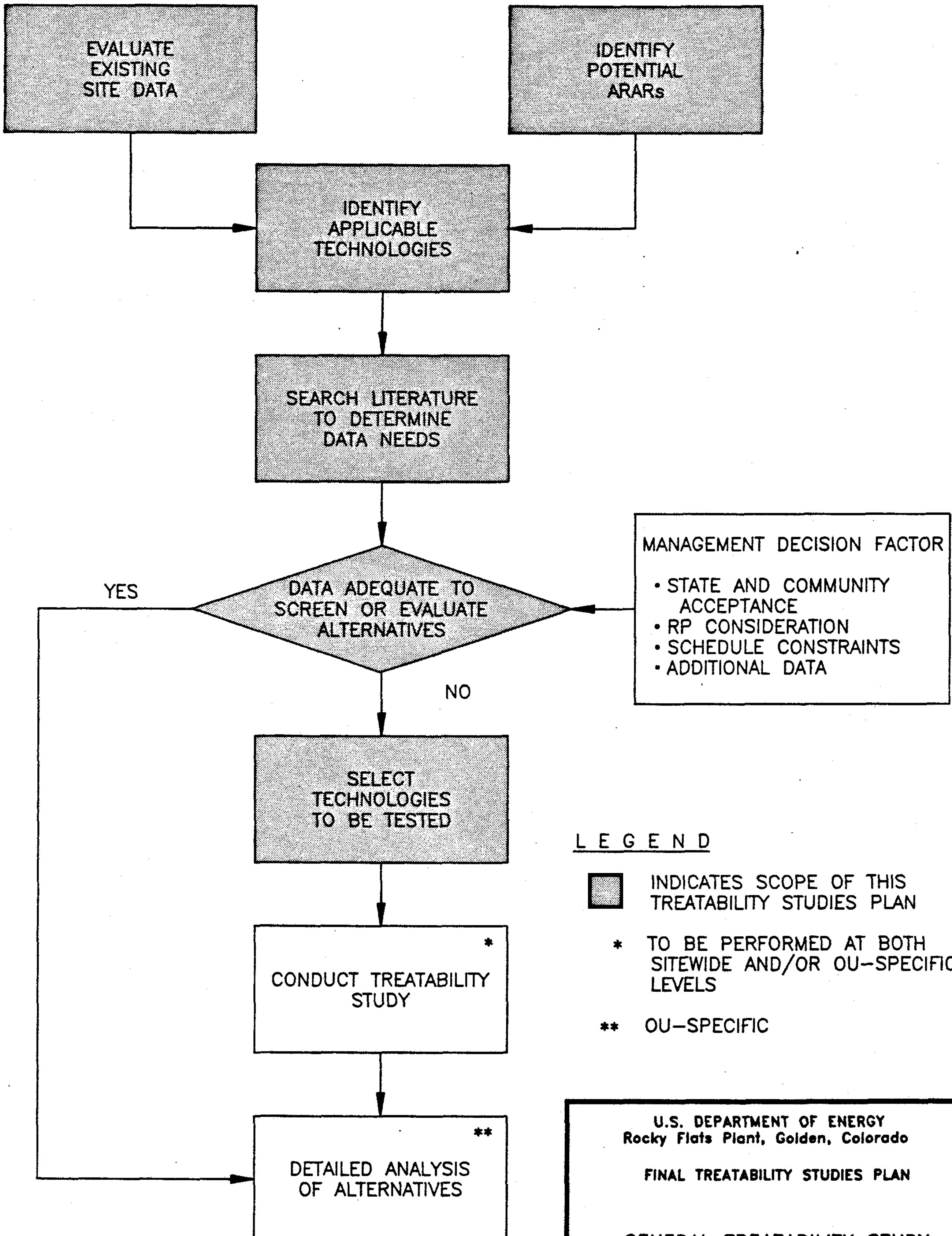
5.0
TECHNICAL APPROACH

The Treatability Studies Plan has been designed to identify candidate technologies for use in Corrective/Remedial actions at the Rocky Flats Plant. The full range of technologies potentially applicable to the types of waste/waste matrix included in this study are identified and then evaluated for suitability for implementation at Rocky Flats. The study then further identifies for which of these technologies the additional information which will be generated during treatability testing may be required for use in alternatives analysis during the CMS/FS. The part a treatability study plays in a site remediation program according to the general guidance from the U.S. Environmental Protection Agency is shown in Figure 5-1. The specific selection process as applied to technologies included in this TSP incorporated some modifications to this process as shown in Figure 5-2. This section discusses the technical approach taken in preparing this Treatability Studies Plan.

Based on site characterization data and anticipated possible or potential ARARs, the potentially applicable technologies were identified. It is not necessary that the site characterization data and ARARs be fully developed since the treatability studies are intended to confirm general feasibility of the selected technologies. For the purpose of the sitewide Treatability Studies Program, it has been assumed (in accordance with the available data) that they are present. Additional site characterization data and ARARs will be reviewed in annual reports as this information becomes available.

The first step in evaluating technologies was the identification of potentially applicable technologies for remediation of the general types of wastes and waste matrices that occur at the RFP. These include organic chemical-contaminated wastes in soil, sediments, surface water, and groundwater; inorganic chemical-contaminated wastes in soil, sediments, surface water, and groundwater; metals-contaminated wastes in soil, sediments, surface water, and groundwater; and radionuclide-contaminated wastes in soil, sediments, surface water, and groundwater. Identification of potentially applicable technologies was based on literature/database searches, review of conference proceedings, EPA guidance documents, government reports, and discussions with equipment vendors and other technical experts.

The process for evaluation of the potentially applicable technologies in shown in Figure 5-2. The identified technologies were processed through a two-stage screening process. The preliminary screening identified those technologies that have potential for use at Rocky Flats regardless of being suitable for the sitewide program. Technology data sheets were prepared for each technology that was retained after the preliminary screening (see Appendix B). The technologies which passed preliminary screening were then screened a second time. This final screening was used to select those



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY STUDIES PLAN

GENERAL TREATABILITY STUDY PROCESS PER EPA GUIDANCE

SOURCE: EPA/540/2-89/058

FIGURE 5-1 MAY 1991

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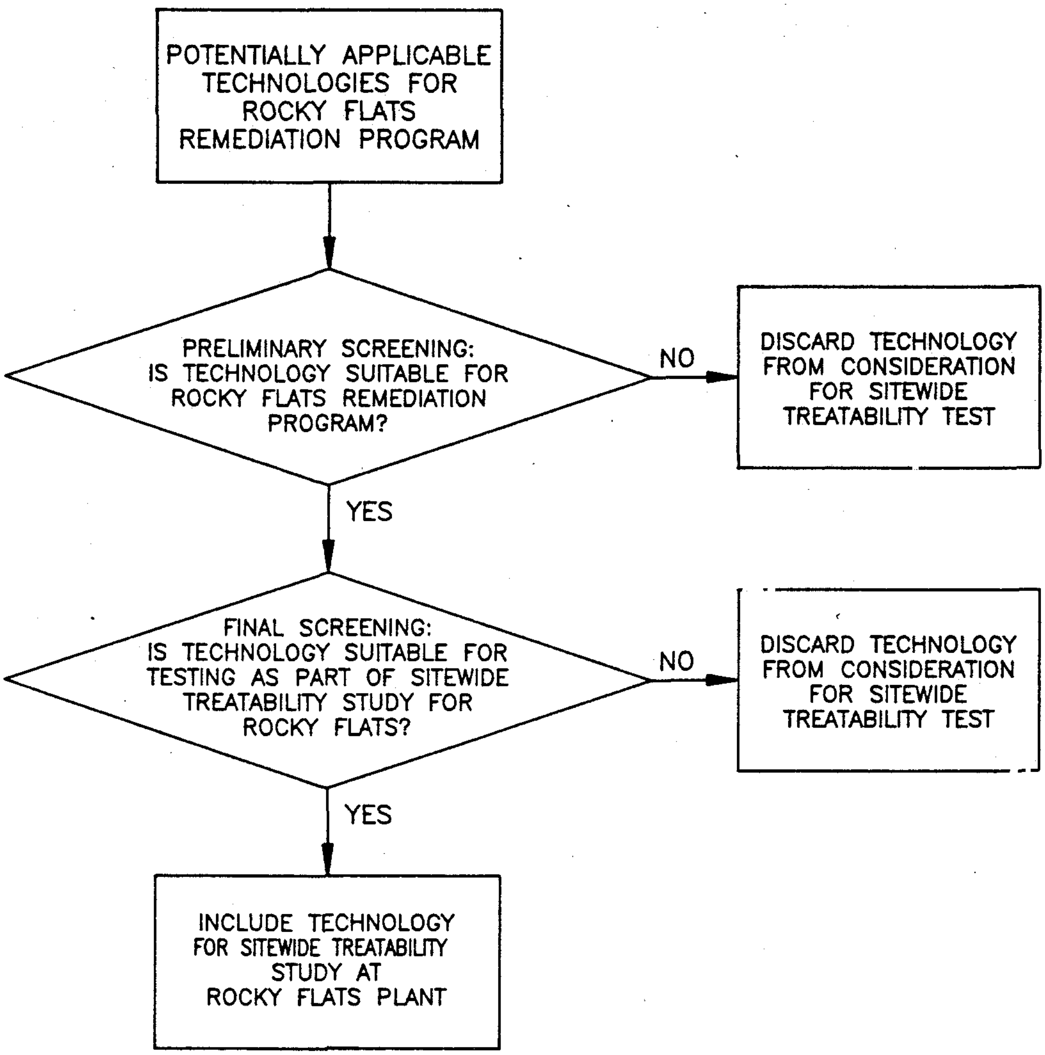


U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY STUDIES PLAN

SPECIFIC SELECTION PROCESS AS APPLIED TO TECHNOLOGIES TO BE INCLUDED IN ROCKY FLATS SITEWIDE TREATABILITY TEST PROGRAM

FIGURE 5-2 MAY 1991

24990050

technologies that should be included in the sitewide program. Section 5.1 presents in detail the screening process and criteria used. Statements of work for the technologies selected for bench or lab testing were prepared (see Appendix C). Work plans will be prepared for conducting lab and bench scale treatability studies for each of the technologies selected (the definitions of lab and bench studies are discussed at length in Section 5.1.4). A review of additional site characterization data, ARARs and technology data available at the time of work plan preparation will take place. The results obtained from the treatability studies may provide important information for the planning of some OU-specific treatability studies programs. This will be accomplished by providing data that demonstrate whether or not a given technology is effective and should be considered further. The results of the lab and bench scale sitewide treatability studies will be incorporated into interim reports.

Innovative and emerging technologies will be examined in annual reports. These technologies will be evaluated for inclusion in the sitewide-treatability program using the same screening procedure utilized in this report. The annual reports will include new information, as available, for the innovative and emerging technologies that have been considered in this report. The annual reports will reevaluate those technologies for possible future inclusion in the sitewide Treatability Studies Program.

The suitability of pilot testing the technologies which were tested at lab or bench scale will be evaluated in annual reports as will those technologies detailed in the TSP for pilot testing. This evaluation will be based on factors including additional site characterization data, ARARs, technology data, relative costs of pilot testing and full scale implementation, and regulatory agency approval.

A procedure for preparing Treatability Study Work Plans was developed to provide the procedures and protocols used in conducting each required treatability study. These procedures for conducting treatability studies will be available for use by the individual CMS/FSs and will help to ensure consistency and completeness of data collection. It should be noted that the sitewide Treatability Study Program will be initiated prior to the individual OU CMS/FSs. However, due to scheduling constraints, not all OU CMS/FSs will benefit from the results of the sitewide program, as some CMS/FS treatability studies will be initiated prior to completion of the later sitewide treatability studies. This is summarized in Figure 3-1.

5.1 TECHNOLOGY SELECTION PROCESS

The technology selection process as presented herein has consisted of identifying and evaluating treatment technologies for inclusion in the Treatability Studies Program. Preliminary site characterization data and available potential ARARs were used to identify the major waste categories and associated media that exist at the Rocky Flats Plant (e.g., volatile organics in soil). Potentially applicable technologies were then identified based on literature/database search, and review of other available information. The potentially applicable technologies were evaluated in a two-step screening process.

The preliminary screening identified those technologies suitable for application at Rocky Flats. The final screening identified which of these technologies to include in the sitewide treatability testing.

The following subsections describe the procedures that were followed to complete the technology selection process. Subsection 5.1.1 describes the procedure for the evaluation of the available data. Subsection 5.1.2 describes the preliminary technology screening process and criteria and Subsection 5.1.3 describes the final screening process and criteria. Subsection 5.1.4 describes what type of treatability studies will be conducted. Subsection 5.1.5 describes the methodology for technologies treatability testing.

5.1.1 Data Compilation

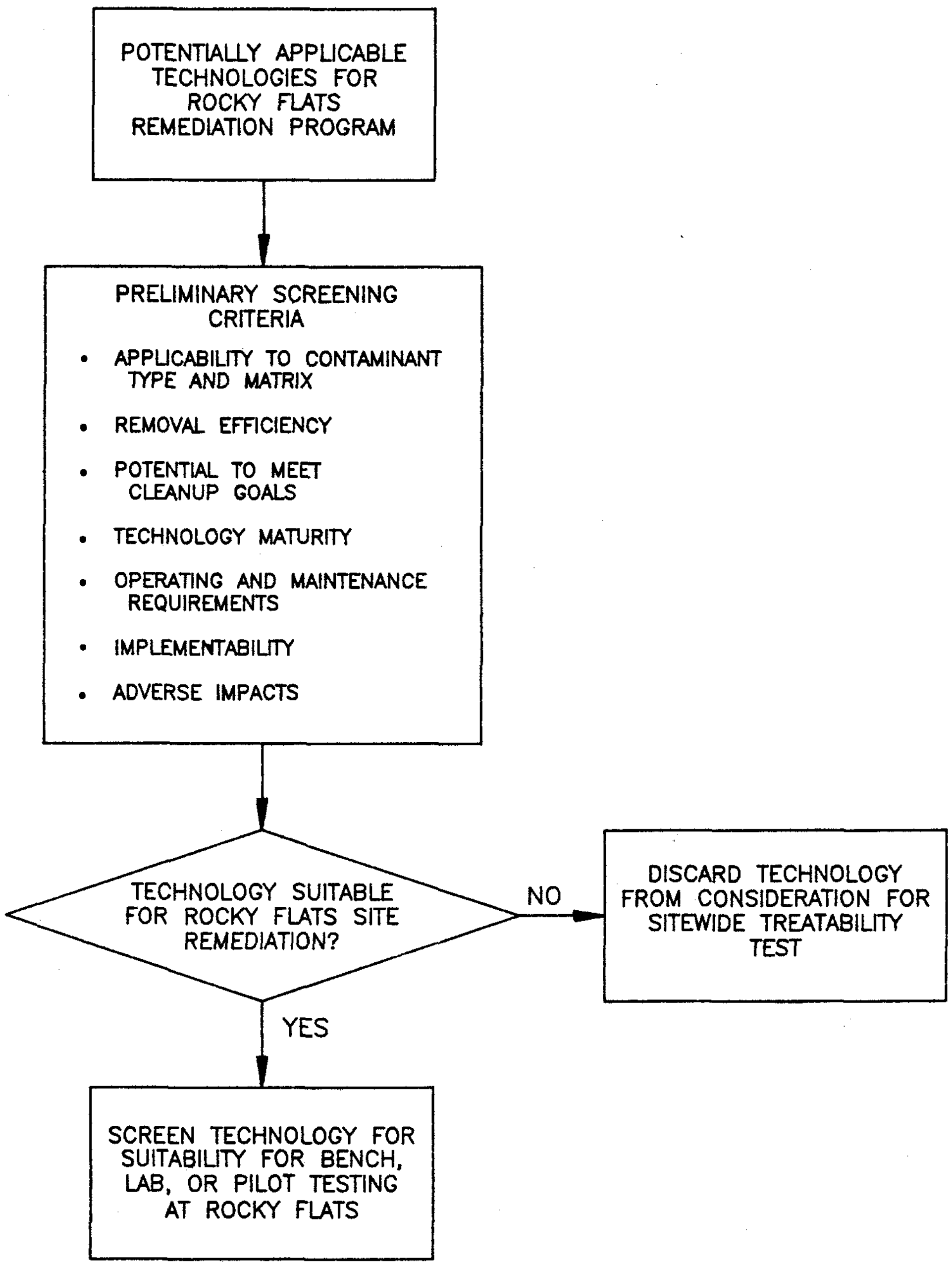
Data compilation required to determine the types and concentrations of contaminants at the Rocky Flats Plant site was derived from the documents listed in Table 4-1 or more appropriate recent revisions.

To facilitate identification of potentially applicable technologies, maximum and minimum concentrations of chemical parameters analyzed in groundwater, surface water, sediments, and soils for each OU were summarized where possible (see Table 4-2). Data were reported and compared to potential ARARs when available. Once compiled, the computerized database was used to identify the predominant contaminants for each environmental medium on a sitewide basis.

5.1.2 Treatment Technology Preliminary Screening Process

The preliminary treatment technology screening consisted of associating the applicable technologies with the major waste categories, and then screening the list to select the candidate technologies for treatability testing. The process used for this preliminary screening is shown in Figure 5-3. The major waste categories were identified for each medium based on the available sitewide contamination data and possible or potential ARARs. The possible or potential ARARs were compared to the available chemical concentration data to identify the contaminants of concern (Table 4-2). The identified contaminants of concern were grouped into major categories for both the soil and water media (e.g., volatile organics, semivolatile organics, metals, radionuclides, and inorganics). When additional data becomes available, this procedure will be repeated in the annual reports to determine if additional categories or contaminants of concern need to be added or existing categories deleted.

Potentially applicable treatment technologies were identified for each major waste category and contaminated medium matrix. They were identified by drawing on a variety of sources including references developed for application to Superfund sites, RCRA Best Demonstrated Available Technology (BDAT) studies, standard engineering textbooks, numerous technology databases, U.S. Department of Energy (DOE) studies, and other project experience.



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FINAL TREATABILITY STUDIES PLAN

PRELIMINARY SCREENING OF TECHNOLOGIES FOR SUITABILITY FOR ROCKY FLATS REMEDIATION PROGRAM

FIGURE 5-3 **MAY 1991**

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The preliminary screening was intended to identify those technologies that have potential for use at Rocky Flats regardless of being suitable for the sitewide program. Criteria for the preliminary screening included the following:

- Applicability - Whether or not the technology in question has potential for use with a specific matrix and contaminant group found at Rocky Flats Plant. Treatment technologies whose primary value pertains to pretreatment or residuals management are not considered applicable.

- Removal Efficiency - Measures the general effectiveness of a technology to remove or destroy a contaminant. This is represented by a percentage or a typical effluent concentration.

- Potential to Meet Cleanup Goal - This is a function of the removal efficiency and the initial concentration. However, even very high removal efficiencies may not be sufficient if the cleanup goal is very low.

- Technology Maturity - Considers the current state of development of the technology. This can range from well proven and commercially available to innovative/emerging.

- O&M Requirements - This covers, in very general terms, whether or not a given technology is labor intensive, has high power or chemical costs, is unreliable, etc. No effort was made to evaluate costs, since this is very site specific. Furthermore, in many cases, meaningful cost data are not available since many innovative technologies were included.

- Implementability - This criterion considers whether the basic equipment needed is readily available, if treatment systems using the technology are commercially available, if use of the technology requires extensive pre- or post-treatment, and if there are any constructability problems.

- Adverse Impacts - This includes an assessment of whether or not a technology produces toxic or hazardous by-products, residuals, sludges or waste streams requiring additional processing and/or treatment.

- Retain - This item indicates whether or not a given technology has potential application for use at Rocky Flats. This is based on the currently identified contaminants, matrices, and ARARs as described elsewhere in this report.

All technologies that are considered to be suitable for application at Rocky Flats have, by definition, passed the preliminary screening. Technology data sheets (Appendix B) were prepared only for the technologies which passed the preliminary screening. These data sheets include a process description, discussion of technology applicability, and advantages and disadvantages of the technology. These technologies are then screened again to determine whether or not they should be included in the sitewide Treatability Study Program.

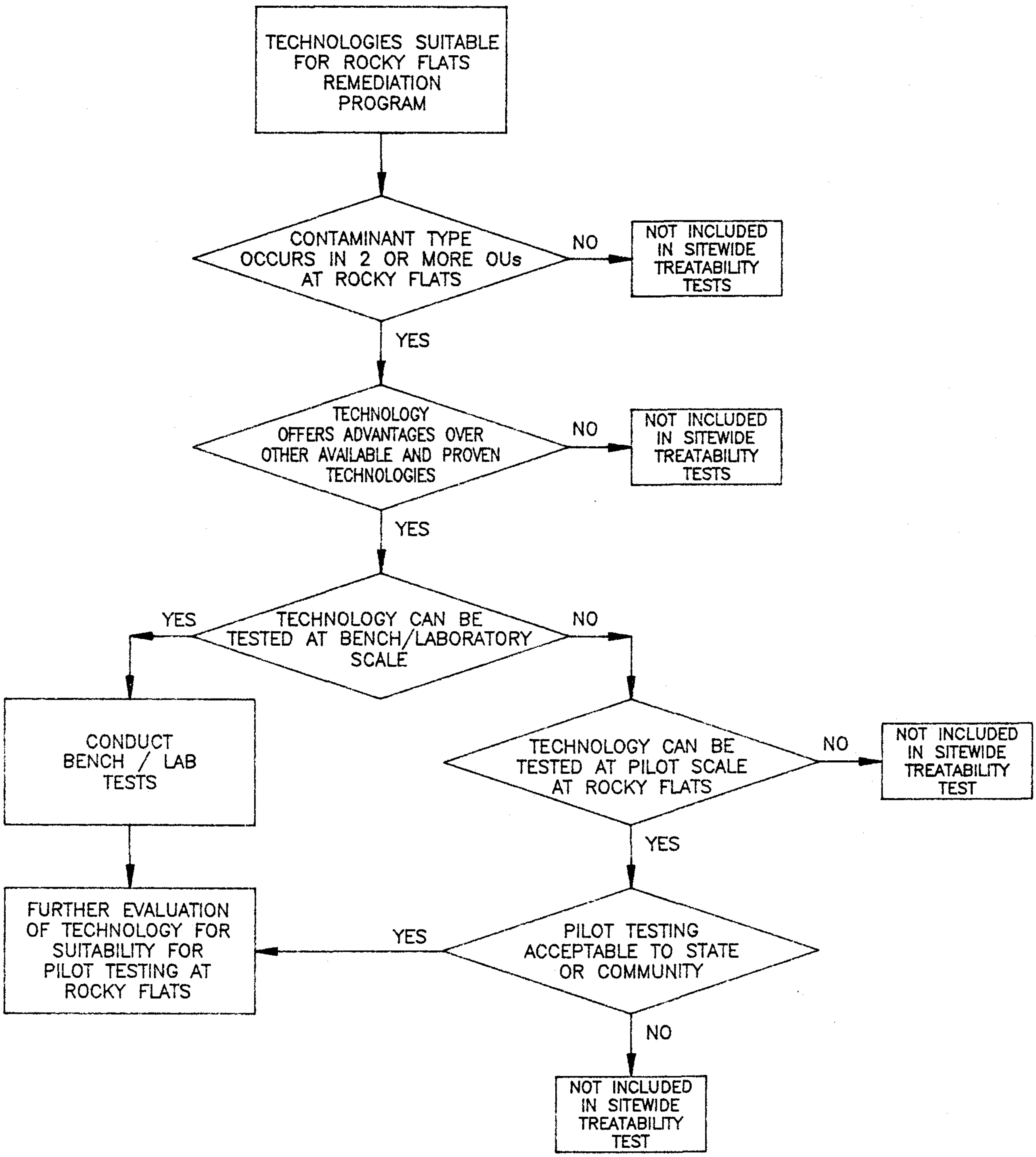
5.1.3 Treatment Technology Final Screening Process

The process used for the final screening to select technologies for inclusion in the sitewide Treatability Studies Program is illustrated in Figure 5-4. The first step in the screening process was to determine if the technology was applicable to a contaminant type found in either surface or groundwater or soils or sediments at two or more operable units. If the technology is not applicable to a contaminant which occurs in two or more OUs it was not considered for inclusion in the sitewide treatability program. Technologies not included in the sitewide program will be addressed in the programs for individual OUs. The technology was then assessed against other proven technologies and if it offered no significant advantages in terms of effectiveness, cost, O&M requirements, or reduction in adverse impacts it was eliminated from consideration. The technologies which were retained after screening according to the first two criteria were included in the treatability program if they could be tested at the bench or laboratory scale. Those technologies which cannot be tested at bench or laboratory scale but can be pilot tested were screened according to an assessment of community and/or state anticipated acceptance of pilot testing and those technologies which were considered favorable according to this criterion were included in a list for consideration for future pilot testing. The technologies selected for bench or laboratory testing will also be considered for pilot testing. The technologies included in the list for potential pilot testing will be evaluated further in interim reports and annual reports to determine if pilot testing is required. The evaluation process for implementation of bench/lab and pilot testing is illustrated in Figure 5-5.

5.1.4 Determination of Type of Treatability Study

Laboratory screening and/or bench-scale testing treatability testing will be conducted on each of the technologies selected for testing at this scale. The term "laboratory screening" refers to tests that will be limited in size and scope such as small-scale jar tests or beaker studies and that are performed on the bench-top. This type of screening will yield primarily qualitative data to be used as indicators of a technology's potential to meet performance goals; the CM/FS or remedial design (RD) stage is an individual OU's remedial action program.

The term "bench-scale" testing refers to bench-top separation, reaction, or other treatment steps that are performed in the laboratory or field with equipment designed to simulate the basic operation of a



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FINAL TREATABILITY STUDIES PLAN

FINAL SCREENING OF TECHNOLOGIES FOR TREATABILITY TESTING AT ROCKY FLATS

FIGURE 5–4 MAY 1991

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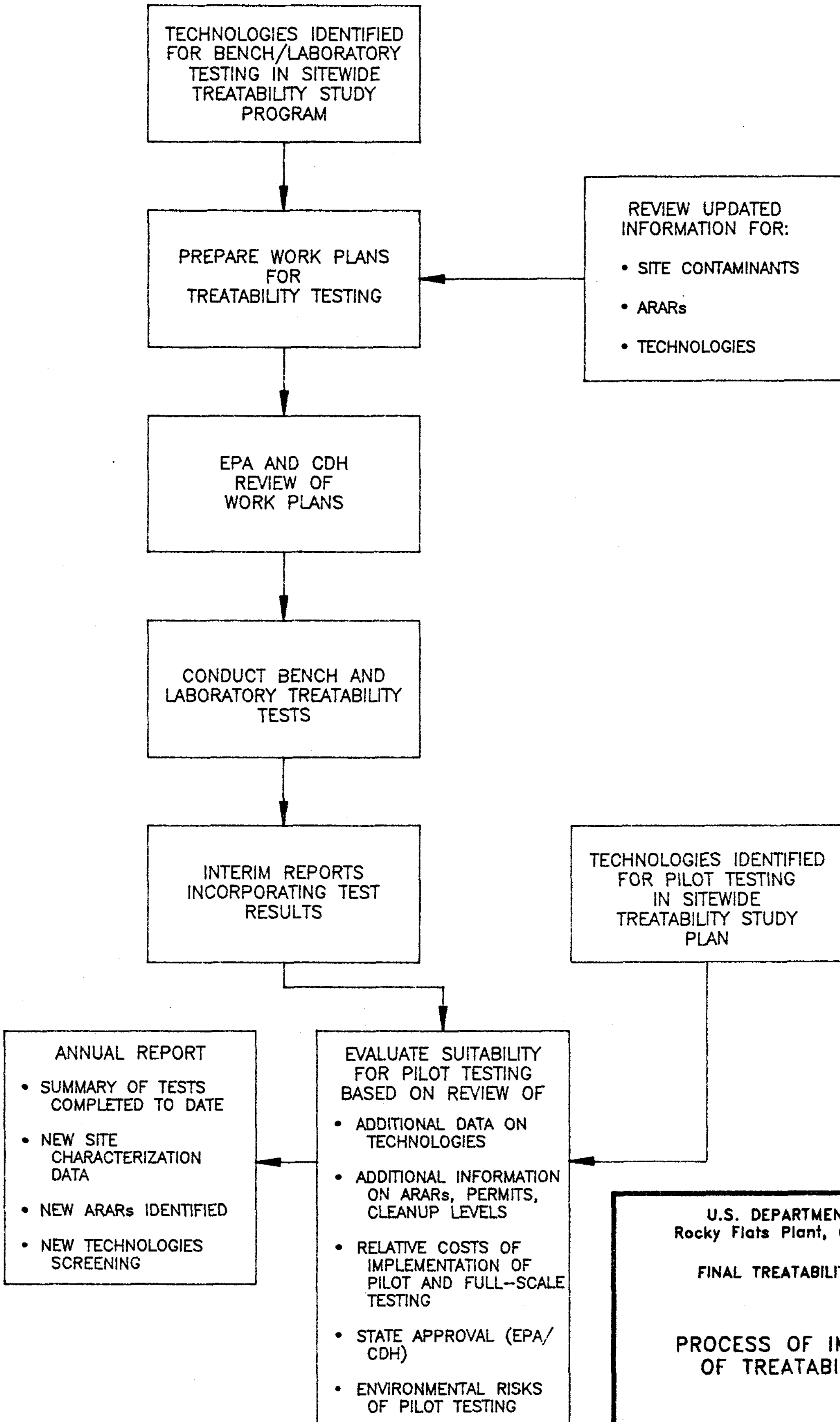

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FINAL TREATABILITY STUDIES PLAN

PROCESS OF IMPLEMENTATION OF TREATABILITY TESTING

FIGURE 5–5 **MAY 1991**

24990080

treatment process. The data from this type of testing will be used to verify that the technology can meet anticipated cleanup goals, and to provide limited cost and design information.

The term "pilot-scale" testing refers to the use of pilot-plant or field-testing equipment with a configuration similar to that of the full-scale operating unit being considered. This level of testing is generally intended to provide detailed design and cost information.

Table 5-1 provides a general comparison of the types of treatability testing tiers including the type of data generated; the analytical level used; the number of critical parameters investigated; the number of replicates required; the study size, usual process type, and waste volume needed; and the typical duration and cost of conducting a study.

For the treatability studies described later, both laboratory testing and bench-scale testing have similar objectives. The primary differences pertain to the quantity of material used for testing and the type of equipment required.

The determination of the level of testing will be made by assessing the technologies under consideration, performance goals, and site characteristics. The choice will be affected by the level of development of the technology in direct application to the contaminants and waste/media at the Rocky Flats Plant. If the technology's validity has not been confirmed, a laboratory screening may be performed. If more quantitative performance data are required, the laboratory screening tier may be bypassed in favor of bench-scale testing. For technologies that are well developed and tested, bench studies are often sufficient to evaluate effectiveness on new wastes.

Bench or laboratory testing can provide useful information as to whether or not a treatment technology will be effective in meeting the required clean-up levels for particular contaminants. Particularly for innovative technologies, bench or laboratory testing can provide a relatively quick assessment of the potential of the technology at a cost much less than that for a pilot test. In some cases a bench or laboratory test can be sufficient to evaluate a technology, whether the technology is well established or innovative, with regard to the particular characteristics of the waste at the site and further pilot testing may not be required. In some cases further pilot testing is required. For example, it may not be possible to adequately test the performance of in-situ treatment technologies in the lab or the scale of a laboratory or bench test may not accurately reflect performance on bulk quantities of material. For some technologies, no useful information can be gained from bench or laboratory testing and direct pilot testing is required.

For example, biological treatment is a technology that has been demonstrated to be effective in the biodegradation of various aqueous wastes, but for which laboratory scale studies are normally required because of the technology's dependence on waste-specific composition and concentration levels. An example of a technology for which both laboratory and bench-scale studies would be bypassed in favor of direct pilot testing is vapor extraction for removal of VOCs from unsaturated granular soil.

5.1.5 Methodology for Technologies Treatability Testing

The technology evaluation process results are summarized in a Technologies Evaluation and Selection Summary which presents the results of the sitewide contamination data review and technology selection as described above. This summary is included as Section 5.2. Statements of Work have been prepared for each of the technologies selected for bench or laboratory testing. The Statements of Work for treatability studies include an overview of the technology to be tested and the key environmental media contamination characteristics to be addressed by treatment. The specific objectives of the treatability study is presented. The Statements of Work include a description of the test approach and will form the basis for preparation of the individual treatability study work plans. The Statements of Work for conducting treatability studies on the selected technologies are presented in Appendix C.

The process which will be used for implementation of treatability testing is shown in Figure 5-5. Work plans will be prepared for those technologies identified for bench/lab scale testing as part of the TSP. Updated information on site contaminant data, ARARs, and technology information will be considered during preparation of the work plans. After EPA and State review of the work plans, the treatability tests will be executed. Interim reports will be prepared incorporating the results of the bench/lab tests. These results will be evaluated to determine if the technology should be tested at the pilot scale. The criteria for this evaluation will include consideration of additional data on the technology, ARARs, site characterization, agency approval, and relative costs for the pilot testing and for full scale implementation to the same criteria. These evaluations will be presented in Treatability Study Annual Reports.

5.2 TECHNOLOGIES EVALUATION AND SELECTION SUMMARY

This section presents the results of the technology selection process for technologies that are appropriate for inclusion in the sitewide treatability testing program.

The technology selection process consisted of identifying and evaluating candidate treatment technologies. Based on the available data and the anticipated ARARs, target contamination problems that appear to exist on a sitewide basis were identified. It should be noted that when possible or potential ARARs were considered, the more stringent site-specific discharge standards listed in Table A-4 of Appendix A were not considered, since it has not been decided how the treated effluent from the pilot-scale tests will be managed. A summary of the site contamination is presented in Section 5.2.1. The candidate technologies that were identified for potential application at Rocky Flats are summarized in Section 5.2.2. The preliminary screening results are presented in Section 5.2.3. A technology data sheet has been prepared for each candidate technology that passed the preliminary screening, and has been included as Appendix B in this document. The final technology screening process results are presented in Section 5.2.4. This process focused on identifying technologies for which treatability studies would be appropriate to aid in the evaluation of applicable technologies conducted as part of the Corrective Measures Study/Feasibility Study (CMS/FS) for each OU. For each of the selected technologies, a Statement of Work was written to form the basis for preparing the detailed Treatability Study Work Plans that will be prepared prior to conducting the treatability studies.

5.2.1 Selection of Target Contaminants

Target contaminants for use in the selection of practical technologies were identified based on a review of maximum concentrations sitewide (Table 4-2) and a compilation of contaminants present at levels above ARARs in two or more OUs for groundwater, surface water, soils and sediments. These target contaminants are listed in Table 5-2.

For practical purposes in selecting technologies, the contaminants were divided into the following groups:

- Inorganics
- Metals
- Radionuclides
- Volatile organics
- Semivolatile organics

All of these groups, except for semivolatile organics, have been detected at levels exceeding ARARs in groundwater and surface water. From the inorganics group, chloride, nitrate, sulfate, and total dissolved solids have been detected at elevated levels in both groundwater and surface water. Metals of concern in groundwater include arsenic, cadmium, chromium, iron, lead, manganese, selenium, and zinc, while in surface water, concentrations exceeding ARARs of aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, zinc, and total dissolved solids were reported in two or more OUs. Among the radionuclides, gross alpha activity exceeded ARARs in two or more OUs in both groundwater and surface water; gross beta activity, radium 226, plutonium, tritium, and uranium (total) in surface water exceeded ARARs in two or more OUs. Values of pH above ARARs were detected in both groundwater and surface water in two or more OUs, while pH values below the ARARs minimum were detected in surface water.

Volatile organic compounds (VOCs) identified as being of concern (e.g., exceeding ARARs in two or more OUs) in groundwater included 1,1-dichloroethene, carbon tetrachloride, methylene chloride, tetrachloroethene, trichloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, and vinyl chloride. In surface water, the VOCs 1,1-dichloroethene, carbon tetrachloride, methylene chloride, tetrachloroethene, and trichloroethene were reported at levels exceeding ARARs in two or more OUs.

In soils, ARARs are not available for many compounds. Those analytes identified as present in two or more OUs in soils include the metal beryllium, the radionuclide parameter gross alpha activity, and plutonium.

5.2.2 Identification of Potentially Applicable Technologies

The approach used to identify candidate technologies entailed segregating the numerous contaminants at Rocky Flats into the five categories of contaminant types listed in Section 5.2.1. Potentially applicable treatment technologies were identified for each major waste category and contaminated medium matrix. They were identified by drawing on a variety of sources, including references developed for application to Superfund sites, RCRA Best Demonstrated Available Technology (BDAT) studies, standard engineering text books, numerous technology databases, DOE studies, and other project experience. These technologies, divided by matrix/contaminant and technology group treated, are given in Tables 5-3A and 5-3B.

Following is a brief discussion of some of the technologies identified as being potentially applicable at Rocky Flats Plant.

5.2.2.1 Water Technologies

Physical/Chemical Processes

Activated Carbon Adsorption of Organics - Activated carbon adsorption is the most widely used and developed technology for treating groundwater contaminated with organics. It is effective for the removal of a wide range of organics from aqueous waste streams. Activated carbon is typically regenerated with a thermal process and the regeneration process can be performed with either off-site or on-site facilities. The use of activated carbon is already planned for OU2.

Adsorption of Inorganics, Radionuclides, and Metals - Sorption processes are used for treatment of inorganics, radionuclides, and metals and are based on the use of materials such as activated alumina and ferrite. These technologies have been used at various sites for treatment of wastewater and contaminated groundwater. Sorption processes are a means of removing contaminants from an aqueous stream. The sorption media are generally chemically regenerated which results in a concentrated side stream requiring further treatment or disposal.

Air Stripping of Volatile Organics - Air stripping is a proven technology for removal of volatile contaminants from water. This process involves the transfer of contaminants from the contaminated liquid phase to the vapor phase by passing the two streams countercurrent through a packed tower. Air emission treatment is generally required with vapor phase activated carbon systems the most commonly used process for this purpose, but other alternatives, such as oxidation and incineration, exist. The vapor phase treatment unit is generally costly.

Catalytic Dechlorination for Semivolatile Organics - Dechlorination involves a chemical process based on potassium polyethylene glycolate (KPEG) to dechlorinate organic molecules containing chlorine. The principal effluent streams produced are a reagent stream and an oil stream free of chlorinated hydrocarbons. The process has been demonstrated to destroy PCBs to low levels.

Chemical Oxidation Technologies for Organics - These technologies are based on the use of oxidizing chemicals, such as hypochlorite, ozone, or hydrogen peroxide to oxidize and destroy the organic contaminants. Other technologies attempt to accelerate the reactions through the use of ultraviolet light. High temperatures and high pressures are used in some oxidation processes such as chlorinolysis to enhance the effectiveness of hypochlorite. Disadvantages are similar to those for inorganic redox: nontarget organics and inorganics can produce undesirable side products and increase oxidant requirements.

Chemical Precipitation for Radionuclides and Metals - Chemical precipitation is the process of making dissolved chemical compounds insoluble so that they can be separated from the liquid. Removal of metals and radionuclides from aqueous waste streams by precipitation is an established treatment method. Precipitation processes can often be tailored to treatment of individual contaminants. This process, however, does generate a sludge requiring treatment or disposal.

Distillation of Volatile Organics - Distillation is a process that involves separating compounds according to their boiling point characteristics. The primary use of distillation is for reclaiming spent solvents from industrial processes, and it is generally applicable only to rather concentrated solutions. The process can be used to separate various volatile compounds or to separate mixtures of organics into light and heavy fractions. The light fraction can usually be recycled or used as a boiler feed, while the heavy fraction requires further treatment.

Electrodialysis for Inorganics and Metals - Electrodialysis is a membrane process used for removal of ionic species from aqueous waste streams. An electrodialysis system consists of ion exchange membranes within an electrolytic cell. An electrical current is applied across cation and anion exchange membranes resulting in a transport of ions through the membranes. The resultant side stream consists of high concentrations of the removed anions and cations which must be treated and disposed.

Electron Beam for Organics - Electron beam treatment is a photochemical process in which chemical decomposition results from exposure to a beam of electrons. The aqueous waste is exposed to high energy electrons produced by an electron beam accelerator. Highly reactive free radicals are formed by the electron treatment and these radicals oxidize the organics in the wastewater. The contaminants may be reduced to carbon dioxide, water and salts if exposed to high doses, while low molecular weight organic aldehydes and acids are formed from incomplete oxidation.

Extraction and Separation Processes for Organics - Extraction and separation processes involve separating the organic compounds from the contaminated liquid. Solvent extraction involves passing a solvent through a mixture that has both soluble and insoluble compounds. The solvent leaves behind the insoluble nonaqueous component. Supercritical extraction uses fluids at their critical temperature and pressure which at the critical points enhances their solvent properties making extraction more rapid and efficient.

The MASX/MADS process involves the use of membranes to effectively separate organics from the liquid. Emulsion liquid membrane separation is another variation of using membranes to separate contaminants from aqueous streams.

Freeze Crystallization for Organics, Inorganics, and Metals - Freeze crystallization involves the removal of heat from the waste to form a crystal structure that naturally excludes contaminants from the water molecule matrix. The ice crystals are recovered and washed with pure water to remove any adhering contaminants. This process produces clean water and a concentrated stream containing the residual contaminant.

Gamma Irradiation for Organics - Gamma Irradiation involves exposing or bombarding the organics with high gamma ray doses which degrade the organics to a certain extent. Process residuals include carbon dioxide, hydrogen chlorine, and partially degraded organics in the liquid or sludge form.

Hydrolysis for Semivolatile Organics - Hydrolysis involves the displacement of a functional group on an organic molecule with a hydroxyl group from water. This is achieved from a neutral reaction with water or catalysis in the presence of an acid or base under elevated temperatures and pressures to promote the reaction. A potential exists for undesirable reactions.

Ion Exchange for Removal of Inorganics, Radionuclides, Metals - Ion exchange is a physical process in which certain ions in aqueous solution are removed and replaced by other, more desirable, ions. For example, ionized uranium compounds can be replaced by chloride ions. This technology has been extensively used for treatment of wastewater and contaminated groundwater. The ion exchange resin used in this process is either chemically regenerated and reused in the process, or replaced with fresh resin. Either method results in a residual that must be further treated and/or disposed.

Miscellaneous Physical/Chemical Processes - This includes processes such as chemical coagulation, clarification, filtration, and microfiltration/ultrafiltration. These processes would be used either as a pretreatment step or as a post-treatment step in conjunction with other technologies discussed herein. Microfiltration has been found to be effective for removing plutonium at Rocky Flats Plant.

Oxidation/Reduction of Inorganics, Radionuclides, and Metals - Chemical reduction-oxidation (redox) reactions are standard processes for breaking certain inorganics such as cyanide into their constituents, or for altering the oxidization state of metals to facilitate additional treatment. The oxidation state of heavy metals, such as chromium or plutonium, are typically adjusted to enhance a subsequent precipitation process. Nontarget organics and inorganics may also react creating undesirable side products and increasing the oxidant (or reductant) requirements.

Reverse Osmosis for Inorganics, Radionuclides, Metals, and Organics - Reverse osmosis processes involve the use of semipermeable membranes. By applying a pressure greater than the osmotic pressure, water is passed through the membrane while particulates, salts, and high molecular weight organics are retained. The retained, highly concentrated solution (retentate) contains dissolved salts, as well as the target contaminants, and requires further treatment or disposal.

Solar Powered Processes for Organics - These processes are intended to offer a more economical method for treating organic wastes. Solar evaporation would be used for concentrating a waste to make it easier to process in later steps. The solar photocatalytic technology is based on using concentrated light beams to facilitate destruction of the organics.

Steam Stripping of Volatile and Semivolatile Organics - Steam stripping involves injecting steam into a solution to volatilize organic compounds. It can be operated as a batch or continuous process. The use of steam makes is possible to strip compounds of lower volatility than those removed by air stripping. Steam stripping is a well demonstrated technology; however, it does generate a concentrate that requires treatment or disposal.

Techtran Inc. Process for Radionuclides - This is a process utilizing a proprietary fine powder that is mixed into contaminated wastewater. This powder absorbs, adsorbs, and chemisorbs most radionuclides in water. Solids separation equipment then removes this material. The process was recently accepted into the EPA Site Demonstration Program.

<u>Biological</u>

Biological Treatment of Volatile and Semivolatile Organics - Biological reactors use microorganisms to remove organic contaminants from water. Most organic contaminants can be biologically degraded by the appropriate microorganisms. High concentrations of some organics or the presence of metals may be toxic to the organisms, and pretreatment may be required. Several different types of reactors exist, such as trickling filters, rotating biological contactors, activated sludge systems, and submerged fixed film reactors. Aerated lagoons have also been widely used for treatment. Some biological systems use additives or special media to facilitate the treatment, such as powdered activated carbon and white-rot fungus. The Sequencing Batch Reactor is a recent development in biological treatment based on using the same treatment vessel for carrying out the various treatment steps in sequence. In general, these methods generate large amounts of nonhazardous sludge requiring disposal.

In-Situ Bioremediation for Semivolatile Organics - In-situ biological treatment of groundwater involves the stimulation of biological growth in the contaminated zone in order to reduce the contaminant concentrations. Microorganisms that can use some or all of the contaminants as substrates will normally exist in a contaminated environment. The microorganisms are stimulated to increase their biological growth and consumption of contaminants through addition of essential nutrients. Aerobic systems also require an oxygen source. In-situ treatment is dependent on geological and hydrological conditions. The process is relatively inexpensive, but the level of cleanup is generally lower than that achieved by biological reactors.

Thermal Processes

Incineration for Organics - Incineration is the controlled combustion of organic compounds under net oxidizing conditions (i.e., the final oxygen concentration is greater than zero). Temperatures in the incinerator are generally in the 1,200 to 2,300°F range which results in the destruction of organic compounds. Removal efficiencies for organics are generally greater than 99.99 percent, while metals are not destroyed but may be oxidized to a different form. Both metals and radionuclides may be emitted in the incinerator off-gas, or may be found in the solid residue. Incineration is a well developed, proven technology for treatment of organic compounds. This technology has been applied to solids, liquids, and gases, and is appropriate for the treatment of soils contaminated with organic compounds.

Many types of incinerators are available. Liquid injection incinerators use a refractory lined combustion chamber into which the fluid being treated is injected using atomizing nozzles. Flue gases leave the unit and must be treated with conventional air pollution control equipment. The submerged quench incinerator is similar, except that the flue gases are passed through a quench chamber at the bottom of the incinerator before leaving the system. The oxygen-enhanced incinerator replaces air used in conventional incinerators with oxygen or an air/oxygen mixture. The advanced electric reactor uses electrically heated fluid walls to pyrolyze waste contaminants. At the high temperatures inorganic compounds melt and are fused into vitreous solids. The circulating bed combustor is a variation of the fluidized bed incinerator, but uses higher air velocity and creates a larger and highly turbulent combustion zone for efficient destruction of organics.

Wet Air Oxidation for Organics - Wet air oxidation is a treatment process whereby contaminated water is subject to high pressure (2,000 psig) and moderately high temperatures (500°F+) in the presence of oxygen (air) to break down and/or destroy the organics. The products from this reaction consist of CO_2 and water, traces of organic chemicals which are products of the breakdown of high complex organic chemicals and possibly ammonia from the breakdown of nitrogen-containing organic chemicals. Supercritical water oxidation is a variation of this process involving higher temperature and higher pressure.

5.2.2.2 Soil Technologies

Physical/Chemical Processes

Chemical Reduction-Oxidation for Organics - Slurried soil is mixed with reducing or oxidizing agents to convert hazardous components to less hazardous forms. Reactions with organics are frequently incomplete, requiring biological or carbon adsorption post treatment.

Glycolate Dechlorination for Organics - This process uses potassium polyethylene glycolate to dechlorinate organic molecules containing chlorine. The process has been demonstrated to destroy PCBs to low levels.

In-Situ Soil Flushing for Organics - Similar to the above except that it is done in place without excavating the soil. Injection and extraction wells or trenches are used to circulate the liquid solutions through the contaminated soil.

Physical Separation for Radionuclides and Metals - Soil contaminants are often found to be associated with particular size fractions of soils, most often the fine particles. In these cases, fractionation of the soil based on particle size can be an effective means of reducing the volume of the material that requires further treatment. The processes used for soil size fractionation include screening, classification, flotation, magnetic separation, attrition scrubbing, and gravity concentration. While physical separation is not actually a treatment process, it is being considered here because it may be a prerequisite to some of the other chemical, thermal, and other treatment operations; or it may be required for sample preparation for some of the treatability tests.

Soil Washing for Inorganics, Radionuclides, and Metals - Soil washing is based on the principle of contaminant removal from soil by washing with a liquid solution. Washing agents include water, acids, solvents, surfactants, or chelators. With the selection of appropriate washing solutions, soil washing technology can potentially be used to remove organics, inorganics, metals, and radionuclides. The wash solution containing the contaminants will require treatment and/or disposal.

TRU Clean™ is a proprietary soil washing system that has a mechanically agitated gravimetric separator to reduce the volume of contaminated soils by concentrating the contaminants.

Vacuum Extraction for Volatile and Semivolatile Organics - Volatile contaminants can be removed from soil using vacuum extraction, which is an in-situ treatment technology that involves the air stripping of contaminants by inducing a vapor flow through the soil. Since this technology involves the transfer of contaminants to the vapor phase, air emission treatment is generally required. The efficiency of the process is highly dependent on the geologic conditions of the soil. This process can be enhanced by the injection of steam or hot air to facilitate semivolatile organic removal.

Biological

In-Situ Bioremediation for Semivolatile Organics - In-situ biological treatment of soils involves stimulation of microbial growth in the contaminated, saturated soil zone by the addition of essential nutrients and possibly inocula of microorganisms. Oxygen addition is also required for aerobic systems. This method is typically used in conjunction with in-situ groundwater treatment. Depending on the depth of soils to be treated, nutrient solutions can be added through sprinkling and subsequent infiltration or by a system of injection wells. As in-situ biological treatment of groundwater, in-situ soil treatment is dependent on geological and hydrological conditions. The process is relatively inexpensive, but the level of cleanup is generally lower than that achieved by aboveground biological treatment.

Land Treatment and Composting for Semivolatile Organics - Soil contaminated with organics can be treated by microbial degradation in a biological land treatment unit by tilling, irrigating, and adding excavated soil. The tilling, irrigating, and adding nutrients maintain soil conditions in which biological degradation can be achieved. The leachate from the land treatment unit may require treatment prior to disposal or reuse in the system. In composting, a highly biodegradable and structurally firm material, such as wood chips, is added to the soil or sediments.

Slurry Reactor for Volatile and Semivolatile Organics - Soil contaminated with organics can be treated by microbial degradation in a biological reactor by mixing the soil with water to create a slurry. The slurry is agitated in the reactor to keep the solids in suspension, and the appropriate conditions for biological degradation are maintained. The slurry is dewatered when biodegradation is complete. The residual water may require treatment prior to disposal or reuse.

Thermal Processes

Incineration for Volatile and Semivolatile Organics - Incineration is the controlled combustion of organic compounds under net oxidizing conditions (i.e., the final oxygen concentration is greater than zero). Temperatures in the incinerator are generally in the 1,200 to 2,300°F range which results in the destruction of organic compounds. Removal efficiencies for organics are generally greater than 99.99 percent, while metals are not destroyed but may be oxidized to a different form. Both metals and radionuclides may be emitted in the incinerator off-gas, or may be found in the solid residue. Incineration is a well developed, proven technology for treatment of organic compounds. This technology has been applied to solids, liquids, and gases, and is appropriate for the treatment of soils contaminated with organic compounds.

Many types of incinerators are available. These units would be used to process the soil directly, or the residuals from soil washing and other processes. Liquid injection incinerators use a refractory lined combustion chamber into which the fluid being treated is injected using atomizing nozzles. Flue gases leave the unit and must be treated with conventional air pollution control equipment. The submerged quench incinerator is similar, except that the flue gases are passed through a quench chamber at the bottom of the incinerator before leaving the system. Rotary kiln incinerators use a rotating combustion chamber which mixes and transports the contaminants through the unit. Fluidized bed incinerators use a suspended bed heated of sand into which the waste material is injected. Multiple chamber incinerators utilize a series of two or more separate combustion chambers arranged to enhance turbulence within the unit.

Innovative incinerator designs include the following:

- Advanced Electric Reactor uses electrically heated fluid walls to pyrolyze waste contaminants.

- High Temperature Fluid Wall - uses a reactor consisting of a porous carbon core surrounded by carbon electrodes that heat the core to 4,000 to 4,500°F. Wastes pass through the core by gravity flow and are quickly incinerated. A nitrogen gas blanket (or fluid wall) prevents the waste from contacting the core walls.

- Infrared Electric Furnace - uses a horizontal woven wire conveyor belt to transport the wastes through the unit. Electric heating elements volatilize the organics and pyrolyze or combust them.

- Molten Glass Incinerator - refractory lined furnace containing a pool of molten glass heated by submerged electrodes.

- Molten Salt/Sodium Fluxing - uses a containment vessel containing a molten sodium carbonate salt bath into which the waste material is injected.

- Plasma Arc Incinerator - uses a plasma torch to disintegrate the wastes.

Finally, solar incineration uses an array of focused heliostats to concentrate the radiant energy from the sun onto a reactor containing the material being processed. The very high temperatures produced result in high destruction and removal efficiencies.

AOSTRA TACIUK Process for Volatile Organics - This process separates and recovers hydrocarbons using a horizontal, rotating vessel. Contaminants are vaporized and pyrolyzed. The hydrocarbon vapor stream exits the unit for further processing.

HT-5 Thermal Distillation Process for Organics - This process heats wastes in a nitrogen atmosphere to vaporize volatile and semivolatile compounds. The resulting hot gases are condensed to recover liquified hydrocarbon products.

Thermal Desorption - This process uses various techniques to heat the soil and desorb the volatile organic contaminants. The process results in a contaminated air stream that requires additional treatment to remove or destroy the volatile organics. In one such system, contaminated soils are excavated and processed through a pug mill or rotary drum system equipped with heat transfer surfaces. An induced airflow removes the desorbed volatile organics and transfers them to a carbon adsorption unit or incinerator.

In-situ processes are also being developed. For example, radio-frequency heating of soil in-place to remove volatile organics is being investigated. Another process uses a hollow auger to drill into the soil and inject steam. Additional treatment is then required to remove or destroy the volatilized organics. Electrokinetic and electroacoustic in-situ processes are also under development.

Wet Air Oxidation for Volatile Organics - In this process, waste is mixed with compressed air, preheated and injected into a reactor, where oxygen in the air reacts with oxidizable material in the waste. The process is primarily applicable to sediments.

Solidification/Stabilization

Solidification/Stabilization for Radionuclides and Metals - Solidification is a process in which contaminants are mechanically bound to solidification agents, reducing their mobility. This produces a solid matrix of waste with high structural integrity. Stabilization usually involves the addition of a chemical reagent to react with the contaminant, producing a less mobile or less toxic compound. Solidification and stabilization are frequently used together and are a well established method for reducing the mobility and toxicity of hazardous wastes. This process generates large volumes of solidified materials requiring disposal.

Numerous solidification agents are available including Portland cement, gypsum cement, masonry cement, polymer impregnated concrete and asphalt. Stabilization using lime and fly ash is also available technology. Polymerization processes using epoxy, polyester, polyethylene polymers and urea-formaldehyde are also being developed.

Encapsulating the contaminants in ceramics, glass, cement, and metal matrices is also being investigated.

Vitrification for Radionuclides - The vitrification process involves heating the waste matrix to a very high temperature and either combining the matrix with molten glass or heating the matrix until it melts. Once cooled, the molten mass solidifies into a stable, noncrystalline solid resistant to leaching of the inorganic, metal, and radionuclide contaminants. Organic components are destroyed by pyrolysis. The process can be conducted either in situ or aboveground; however, the process is generally expensive.

5.2.3 Preliminary Screening of Technologies for Applicability

The technologies listed in Tables 5-3A and 5-3B were screened to determine which ones have potential applicability at Rocky Flats. The criteria used for this evaluation are described in Section 5.1.3. In order to facilitate the screening process, tables were prepared listing the technologies versus the screening criteria. These tables are included herein as Table 5-4A for Groundwater and Surface Water, and Table 5-4B for Soil and Sediments.

Tables 5-5A and 5-5B list the technologies that were retained for further screening. A list of those dropped, along with a brief explanation of why they were dropped, is provided in Table 5-6.

5.2.4 Final Selection of Technologies for Treatability Studies for Testing

The technologies listed in Tables 5-5A and 5-5B were then final-screened to determine which ones should be included in the sitewide Treatability Studies program. The criteria used for this evaluation are described in Section 5.1.3. The screening process is presented in Table 5-7A for Groundwater and Surface Water, and Table 5-7B for Soils and Sediments.

Screening for technologies applicable to treatment of semivolatile organic compounds in surface water or groundwater was not included in Table 5-7A since there were no semivolatile compounds which were identified in Table 5-2 to exceed ARARs in two or more OUs. Screening of technologies applicable to treatment of volatile organic compounds, semivolatile organic compounds, and inorganics in soil or sediments was not included in Table 5-7B because none of the contaminant types were identified in Table 5-2 to exceed ARARs in two or more OUs.

Table 5-8 summarizes the technologies selected for bench or laboratory scale. Table 5-9 summarizes the technologies identified for pilot scale testing the sitewide testing program. Five water treatment technologies were selected for bench or laboratory testing. Ion exchange, oxidation/reduction, and adsorption are applicable to metals and radionuclides while TRU/Clear™ and ultrafiltration/microfiltration are applicable to radionuclides. Four technologies applicable to treatment of volatile organic compounds in surface water or groundwater were identified for pilot testing: ozonation, peroxide oxidation, ultraviolet oxidation, and ultraviolet photolysis. The technologies selected for bench or laboratory testing may also be pilot tested after completion of the bench/lab tests. Eight soil or sediment treatment technologies were selected for bench or laboratory testing. Physical separation, soil washing, and the stabilization/fixation technologies, epoxy polymerization, polyester polymerization, and portland cement are applicable to metals and radionuclides. Magnetic separation, TRU Clean™, and masonry cement stabilization are applicable to radionuclides. The technologies selected for bench or laboratory testing may also be pilot tested after the bench/lab tests are completed. Appendix C includes Statements of Work only for each technology selected for bench or lab testing. These Statements of Work (SOW) are general descriptions of the goals and requirements for each study. These SOWs, along with the guidelines presented in Section 6.0, will form the basis for preparing detailed Treatability Study Work Plans for each technology. The need for pilot testing will be evaluated in the Treatability Study Annual Reports after the results from the bench and laboratory tests have been presented in interim reports. The decision on pilot testing will incorporate a review of additional information on site characterization, ARARs, technologies, state and EPA input, and costs for pilot testing and full scale implementation of the technologies. For those technologies which are ultimately selected for pilot testing, Statements of Work will be prepared and published in the Treatability Study Annual Reports. Prior to each pilot test, the necessary Work Plans will be developed according to the guidelines in this Sitewide TSP.

Information on innovative and emerging technologies will be included in the Annual Reports. Innovative and emerging technologies will be screened by the same criteria used in this report. The Annual Reports will provide the relative costs for the selected technologies. These costs will be considered in developing the priority and sequence for conducting the tests in conjunction with management and technical factors.

6.0
PROCEDURES FOR PREPARATION OF THE TREATABILITY STUDY WORK PLANS

Treatability testing will be conducted on each of the selected technologies to provide data to identify and evaluate appropriate remedial alternatives. Before conducting treatability testing for each technology, a Treatability Study Work Plan will be written. This plan will describe the manner in which the specific treatability test will be conducted. Although these treatability tests are not specifically a program in support of a CERCLA FS, the plans will generally conform to CERCLA Treatability Study guidance. The content of a typical Treatability Study Work Plan geared to laboratory screening and bench-scale testing is described in the following sections. The following 11 elements will be addressed in the plan: scope, test objectives, data quality objectives (DQOs), experimental procedures and equipment, data management, analysis of results, regulatory requirements for on-site/off-site testing, residuals management, Health and Safety Plan, Sampling and Analysis Plan, and reporting and scheduling. The treatability studies will be performed after satisfying the National Environmental Policy Act (NEPA) requirements for preparation of environmental assessments. If additional studies are to be performed, additional environmental assessments may need to be developed. The following subsections describe the content of each of these elements.

6.1 RE-EVALUATION OF TESTING NEEDS

During the time it takes to develop the Treatability Study Work Plans, it is possible that new technologies may be introduced that have potential applicability to Rocky Flats Plant. Additionally, new site characterization data may become available and/or additional ARARs may be identified that could effect technology selection. Additional information may be available from treatability tests conducted as part of interim actions at individual OUs. This additional data from testing of technologies at individual OUs may be used to modify the testing to be conducted as part of the sitewide Treatability Studies Program. Likewise, information developed in the sitewide Treatability Studies Program will be considered in the preparation of OU-specific Treatability Study Work Plans. For those technologies which will be tested in the sitewide program prior to an OU program on the same contaminant, the sitewide study results will be evaluated, and the OU testing may be modified or eliminated as a result.

Therefore, a re-evaluation of testing needs will be done during work plan preparation. The purpose of this re-evaluation is to include any new technologies that are potentially applicable on a sitewide basis.

6.2 SCOPE

The scope will provide an overall description of the treatability study. It will provide relevant background information on the site and summarize the existing waste characterization data (type, concentration, and distribution of contaminants of concern). It will specify the type of study to be conducted (laboratory, bench, or pilot). In addition, it will briefly describe the technology to be tested. A schematic flow diagram showing the material to be treated, the unit process being simulated, the main process streams, and any process residuals will be generated.

6.3 TEST OBJECTIVES

This section will define the objectives of the treatability test and the intended use of the data. Treatability testing programs in which laboratory screening and bench-scale testing are undertaken usually have technology validation and/or performance evaluation as objectives. Technology validation involves obtaining a "yes" or "no" answer on whether the technology is effective in treating the waste or contaminated media and should be considered further. Performance evaluation entails measurement of the success of treatment against established criteria in terms of treatment efficiency, effluent quality, or residual concentrations in the environmental medium. In assessing performance, objectives may also be set for reproducibility of treatment over the expected range of site and waste/media characteristics, as well as for quantitative and qualitative determinations on the resultant range of treatment residuals. The test objectives will be based on anticipated cleanup goals as determined by the possible or potential ARARs determination or, when such goals do not exist, on levels that are protective of human health and the environment as determined by risk assessments, if available.

6.4 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) will be specified in order to define the data quality needs of the project. In accordance with the EPA guidance document Data Quality Objectives for Remedial Response Activities (U.S. EPA 1987a), a three-stage process will be used to develop the DQOs. In Stage 1, the types and magnitudes of decisions to be made will be determined. This process will entail evaluating the existing data and specifying the objectives of the treatability study (e.g., data quality needs would be different if the objective is to assess the validity of the technology or to confirm the attainment of a treatment standard). In Stage 2, the criteria for determining data adequacy will be stipulated and the sampling approaches and analytical procedures will be selected. During Stage 3, the methods for obtaining data of acceptable quality and quantity will be selected and incorporated into the Quality Assurance Addendum (QAA) of the Treatability Study Work Plan.

The five analytical levels that are established in the EPA's DQO guidance are included as Table 6-1 and will be applied to the treatability studies. When laboratory screening studies are being performed, analytical levels I and II will be used. Confidence limits will be wide (±25 percent) in keeping with the characteristics of this level of study (i.e., low cost, quick turnaround, and limited quality assurance/quality control [QA/QC]). When bench-scale tests are required, analytical levels II through V may be used.

Confidence limits will be narrower to meet the quantitative objectives of obtaining more detailed waste characterization and performance testing data. However, even in bench-scale work, data quality for some samples and unit processes may be allowable at lower levels. This is based on necessary turnaround times for use of the data in process decisions or based on the nature of the process under study or its performance objective. The objectives and limitations of using the lower analytical levels must be described in the treatability study work plans.

6.5 EXPERIMENTAL PROCEDURES AND EQUIPMENT

This section will describe the experimental design, the methodology, and the equipment that will be used during testing. The discussion on experimental design will identify the volume of waste material to be tested, the critical parameters, the levels of testing, and the type and amount of replication. The methodology discussion will include the types of methods that will be used; the specific steps, however, that will be followed during testing will be described in the standard operating procedures (SOPs) provided in the individual OU work plans. A list of the equipment, materials, and reagents will be prepared and will include the specifications for each item (e.g., quantity, volume/capacity, calibration or scale, equipment manufacturer and model number, and reagent grade and concentration). The measurements to be taken during the tests and the samples to be taken for laboratory analysis (number, size, time, and preparation methods) will also be specified.

The logistics of testing will be described in this section, while the details of collecting the samples to be tested will be described in Section 6.11. The locations where waste or contaminated media samples are to be obtained, or the sector of the contaminated area to be studied, will be identified on a site map and one or more cross sections. The on-site or off-site testing location will be described in terms of the facilities supplied, manpower involved in conducting the tests, sample storage areas, and other pertinent details. If a proprietary treatment process is being tested, any limitations on knowledge of the process operation or reagents used will be discussed. All sampling and test procedures will be documented in data log books.

6.6 DATA MANAGEMENT

The section on data management will describe the procedures for recording observations and raw data in the field or laboratory including the use of bound notebooks, data collection sheets, photographs and electronic format. If proprietary processes are involved, this section will also describe how the confidential information will be handled and what data will be supplied by the vendor. Analytical data will be supplied both in hard copy and in a computer format. A Rocky Flats Environmental Data System (RFEDs) module will be developed for the treatability testing/results use and compilation. Data tables generated for both field and laboratory data will be checked against the source document using procedures outlined in this section.

6.7 ANALYSIS OF RESULTS

The analysis of results section will describe the approach that will be used to present and interpret the data upon completion of the treatability test. It will describe how the data will be summarized and evaluated to determine the validity or performance of the treatment process. It will describe the data-checking process that will be used to assess all data for precision (relative percent difference for duplicate matrix spikes), accuracy (percent recovery of matrix spikes), and completeness (percentage of data that are valid). In addition, if data are to be generated on cost (i.e., reagent use, power and water consumption, treatment rate, etc.) or equipment design (i.e., waste feed, mixing, solids separation, etc.), it will discuss how the test data will be analyzed to yield these results.

This section will also describe the statistical analysis procedures that will be followed, if applicable. If laboratory screening is to be conducted, a statistical analysis of the data will not be appropriate. However, the results will be interpreted qualitatively and described as such. If bench-scale or pilot-scale testing is to be conducted, a statistical analysis will generally be appropriate and, therefore, the procedures will be described.

6.8 REGULATORY REQUIREMENTS FOR ON-SITE AND OFF-SITE TESTING

Treatability studies for RFP wastes will be subject to CERCLA requirements and possibly to RCRA permitting and operating requirements. These requirements will vary depending on whether the studies are conducted on-site or at an off-site laboratory or testing facility.

When off-site treatability studies must be conducted, sample collection and shipping restrictions will be followed to comply with the Sample Exclusion Provision (40 CFR 261.4(d)) of RCRA. This provision, which exempts environmental samples collected for the sole purpose of determining their characteristics or composition from regulation under Subtitle C of RCRA, has been expanded to include environmental samples used in small-scale treatability studies (53 FR 27301). This expanded provision is referred to as the Federal Treatability Study Exemption Rule. In accordance with this rule, samples that are collected, stored, or transported to an off-site laboratory or testing facility will be exempt from the RCRA generator and transporter requirements (40 CFR Parts 262 and 263) by following these guidelines:

- Do not collect or ship more than 1,000 kilograms (kg) of any nonacute hazardous waste, 1 kg of acute hazardous waste, or 250 kg of soils, water, or debris contaminated with acute hazardous waste per waste stream per treatment process.

- Check the sample package. It must not leak, spill, or vaporize from its packaging during shipment, and the transportation of each sample shipment must comply with U.S. Department of Transportation (DOT), U.S. Postal Service (USPS), or any other applicable regulations for shipping hazardous materials. All sample packages must be surveyed for radioactivity following Rocky Flats Plant and DOT requirements. Packages must be appropriately labelled after surveys, according to DOT regulations (49 CFR 173).

- Check the permit status of the laboratory or testing facility. The samples can only be shipped to a laboratory or testing facility that is exempt under 40 CFR 261.4(f) or that has an appropriate RCRA permit or interim status. If the samples are anticipated to contain radionuclides, all laboratories (including analytical laboratories) handling the samples must be licensed by the Nuclear Regulatory Commission (NRC) or the applicable state agency if they have NRC licensing authority for handling, analyzing, treating, or storing radioactive materials. The license must be inclusive of the radionuclides expected and allow amounts of those radionuclides in excess of the quantities anticipated.

When on-site treatability studies are to be conducted, substantive compliance with federal, state, or local requirements will be demonstrated. If necessary, permits will be obtained. Treatability studies requiring sample amounts in excess of the Federal Treatability Study Exemption Rule must be conducted on site. Additionally, it may be preferred to conduct some studies on site because of the types of contaminants anticipated or the technology to be tested.

For each treatability study conducted, the following information must be maintained for each individual waste stream:

- The date the sample was collected

- The date the sample was received at the treatability study unit

- Total quantity in kg of "as received" waste in storage per day at the treatability study facility

- If the "as received" waste sample was stored prior to initiating the treatability test, where it was stored

- Quantities and types of waste subjected to treatability studies

- Date treatment was initiated, and the amount of "as received" waste introduced to treatment each day. (If the treatment process is conducted in a glovebox AND an individual sample is treated in multiple runs, THEN the day the entire sample enters the glovebox is the date of treatment initiation for the sample)

- Dates of initiation and conclusion of each treatability test

- Final disposition of residues and unused sample from each treatability study (such as which RCRA-permitted hazardous waste storage area are the residues and unused samples stored in)

- Records of any spills or releases

- Records must be kept for a minimum of 3 years after completion of each treatability study that show compliance with the treatment rate limits, and the storage time and quantity limits.

This recordkeeping information will be included in the Treatability Study Annual Report to the CDH. In addition to the following information, the Annual Report identifies the treatability studies proposed for the current year.

Monthly reporting will be required for each treatability study. These reports will include the following:

- Waste stream studied

- Treatability test number

- Date sample collected

- Where sample stored prior to treatment

- Date treatment initiated

- Initial sample weight

- Date treatment concluded

- Final residue and unused sample weight

- Where residue stored prior to return to permitted storage area

- Date residue returned to permitted storage area.

This information will be presented in a table format with one table per waste stream/process. This information will be provided to EG&G RCRA Permitting Division on a monthly basis. The state will also be notified of the intent to conduct any new treatability study. The RCRA Permitting Group will submit the notifications.

6.9 RESIDUALS MANAGEMENT

A section on residuals management will be included to describe the management of all treatability study residuals including unused waste not subjected to testing; treated waste; treatment residuals; laboratory samples and sample extracts; used containers or other expendables; and contaminated protective clothing and debris. It will include estimates of both the types and quantities of residuals expected to be generated during treatability testing based on knowledge of the treatment technology and the experimental design. The residuals management section will consider the status of testing residuals relative to RCRA waste characterization and disposal requirements. It will describe how treatability study residuals will be analyzed to determine if they are hazardous wastes or contain hazardous substances at levels of concern relative to disposal, and will specify whether such wastes will be returned to the site or shipped to an acceptable treatment, storage, or disposal facility (TSDF) permitted under Subtitle C of RCRA. In the latter case, this section will also identify the waste generator and delineate the parameters that will be analyzed for properly manifesting the waste and for obtaining disposal approval.

Some samples and residuals may contain only radioactive contamination and others may be "mixed" wastes, meeting RCRA hazardous waste definitions and containing radioactive components. These materials cannot be disposed as RCRA wastes. All residuals must be screened for radioactivity prior to any decision on disposal. Any original samples and any residuals meeting the definition of a radioactive material in 49 CFR 173.403 must be returned to the Rocky Flats Plant, regardless of their status as hazardous waste.

Off-site laboratories will be allowed to return any unused sample or residues to the Rocky Flats Plant under the Treatability Study Sample Exemption Rule if storage time limits are not exceeded. In accordance with 40 CFR 261.4(f), the laboratory or testing facility must not exceed the storage time limit of 90 days from the time the treatability study was completed, or no more than 1 year from the sample shipment date from the RFP to the facility. The residues or unused samples generated from on-site treatability studies will be managed as RCRA hazardous wastes. This regulation requires that residues or unused samples from the treatment process must not be stored at the treatability test location for more than 90 days. However, residues can be stored in a RCRA-permitted storage area indefinitely or until manifested and shipped off-site for disposal.

6.10 HEALTH AND SAFETY PLAN

A section will be included that describes how health and safety procedures will be used to address the hazards associated with treatability testing. This Health and Safety Plan (HSP) will be prepared in accordance with the EG&G Environmental Restoration Sitewide Health and Safety Program Plan. Hazards addressed include, but are not limited to, chemical or radiological exposure; fires, explosions, or spills; generation of toxic or asphyxiating gases; physical hazards; electrical hazards; and heat and cold stress. The HSP will include procedures for treatability studies that are conducted on site or at an off-site laboratory or testing facility permitted under RCRA, including research, development, demonstration facilities, and facilities that are conditionally exempt from RCRA 40 CFR Part 260 Subtitle C regulation by the treatability study sample exemption. Health and safety at off-site facilities will be addressed to the extent necessary to (1) ensure adequate response to any special hazards imposed by the samples or treatability testing procedures, and (2) protect and inform personnel involved in the performance of the treatability testing.

6.11 FIELD SAMPLING PLAN

A Field Sampling Plan (FSP) will be written to define the field sampling objectives and procedures where specific field activities are required to support the conduct of treatability studies. The FSP will include the sampling objectives; the type, location, and number of samples to be collected; the sample numbering system; the necessary equipment and procedures for collecting the samples; the sample chain-of-custody procedures; and the required packaging, labeling, and shipping procedures. The field sampling procedures described in the FSP will be in accordance with the ER Program Standard Operating Procedures (SOP). A specific FSP will be included as a part of each individual treatability study work plan.

6.12 AMENDMENT OF QUALITY ASSURANCE PLANS

A sitewide Quality Assurance Project Plan (QAPjP) for environmental restoration activities required by the Federal Facilities Agreement and Consent Order, also known as the Interagency Agreement (IAG), has been developed and submitted to the EPA and CDH. The QAPjP describes the sitewide Quality Assurance Program policy, organization, functional activities, and requirements for the RFP Environmental Restoration Program. The content of the QAPjP is based on DOE and EPA quality assurance requirements guidance documents, specifically ASME NQA-1 and EPA QAMS-005/80, that are required by DOE.RFP SOP 5700.6B and the IAG, respectively.

For specific environmental restoration activities (e.g., treatability studies) and/or specific sites (e.g., operable units) that require development of a site- or activity-specific work plan, a Quality Assurance Addendum (QAA) to the QAPjP will be developed. The QAAs will outline the site- or activity-specific project management structure, data quality objectives, standard operating procedures, analytical requirements, specific quality control measures, and quality verification activities to be taken to meet the quality assurance requirements that are applicable to that particular site or activity. The QAAs will follow the format presented in the QAPjP, but will not restate applicable sitewide requirements and controls. See Section 3.4 for a discussion of the relationship of the TSP to the Quality Assurance Plan.

6.13 REPORTING AND SCHEDULES

This section will describe the preparation of interim reports documenting the results of the treatability study. Interim reports will only be generated when the treatability studies on a selected technology involve more than one tier (e.g., laboratory screening followed by bench-scale testing). In this case, interim reports will provide a means for determining whether to proceed to the next level of testing. In addition, the preparation of monthly reports that detail current and projected progress on the project will be described.

The proposed organization of the interim reports is included as Table 6-2. This format includes four major sections: Introduction; Conclusions and Recommendations; Treatability Study Approach; and Results and Discussion. The suggestions concerning the content of each of these sections, which is included in the EPA Guide for Conducting Treatability Studies under CERCLA (1989), will be used as a general guideline. The report will provide only limited information on the applicability of the technology to specific OUs at the Rocky Flats Plant. Application of this information to specified OUs will generally be left for the decision process in each CMS/FS.

The schedules for preparation of each work plan, performance of the requisite testing programs, and reporting of results will conform to the schedule shown in Section 7.0, Table 7-1.

7.0
DELIVERABLES AND SCHEDULE

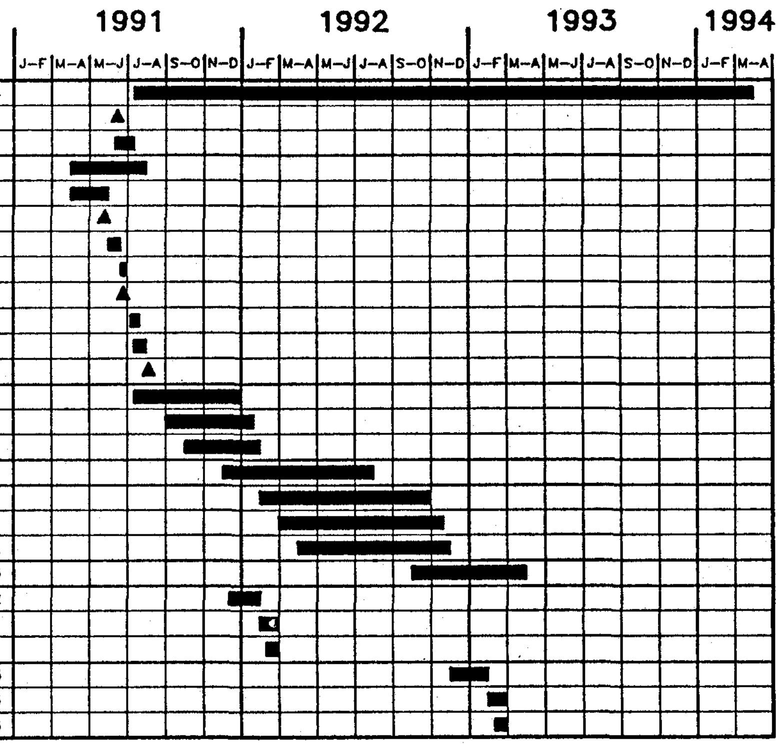
The Rocky Flats Final Inter-Agency Agreement (IAG) dated January 22, 1991 calls for draft and final sitewide treatability studies plans in 1990 and reporting of results in 1993. Preliminary draft submittals for Rocky Flats Plant review will precede document submittals as drafts to Region VIII Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH).

The schedule and deliverable documents for the sitewide Treatability Studies Program are shown in Table 7-1. The revision of the Treatability Studies Plan (TSP) during August through October 1990 was based on a review of a limited database of site contamination data, principally from Operating Units (OUs) 1, 2, 4, 7, and 11. This review was conducted initially to permit the selection of practical technologies in Section 5 of this document. A comprehensive review of proposed and potential Applicable or Relevant and Appropriate Requirements (ARARs) was performed to facilitate the identification and screening of innovative and emerging technologies. Other sitewide program documents may be issued in final form on or after the scheduled submittal date for the TSP. In accordance with IAG requirements for the TSP, a review of these documents for adequacy with respect to treatability work will be conducted after submittal of the plan. Recommendations for revisions or addenda to these supporting sitewide documents will be made in a separate memorandum to the Environmental Restoration (ER) program management at the Rocky Flats Plant.

Both practical and innovative/emerging treatment technologies will be included in the sitewide treatability studies, with technology evaluation-level studies (usually bench-scale testing) planned for the 1991-1992 study period. Figure 7-1 provides an overall schedule for the sitewide Treatability Studies Program. Figure 7-2 depicts a tentative schedule for implementation of one individual technology treatability study.

The schedule includes the preparation of both interim reports and the Treatability Study Annual Reports as discussed in Section 3.3. Technology evaluation level studies will be conducted on any new technologies presented in the Annual Reports only after agency review and comment.

	START	FINISH
TREATABILITY STUDIES	3 JUL 1991	31 MAR 1994
Submit Final Treatability Studies Plan (TSP)	3 JUN 1991	3 JUN 1991
EPA/CDH Review and Approve TSP (2)	3 JUN 1991	3 JUL 1991
Treatability Study–Environmental Assessment	29 MAR 1991	31 JUL 1991
DOE Headquarters (HQ) Review/Approve Mini – EA	29 MAR 1991	29 MAY 1991
EG&G/RF Submit Working Draft Mini – EA	29 MAY 1991	29 MAY 1991
DOE HQ Staff Review/Comments on Mini – EA	3 JUN 1991	17 JUN 1991
RF NEPA Finalize EA	18 JUN 1991	25 JUN 1991
Finalize Mini – EA to DOE HQ	26 JUN 1991	26 JUN 1991
DOE HQ Review/Approval	2 JUL 1991	17 JUL 1991
DOE HQ Approval	10 JUL 1991	31 JUL 1991
DOE HQ Issue Approval	31 JUL 1991	31 JUL 1991
Prepare Work Plans	3 JUL 1991	17 FEB 1992
EPA/CDH Review	15 OCT 1992	28 FEB 1992
Resolve Comments & Finalize	16 NOV 1992	16 MAR 1992
Bench–Scale Treatability Studies	1 DEC 1991	31 JUL 1992
Interim Report	1 FEB 1992	30 OCT 1992
EPA/CDH Review	1 MAR 1992	16 NOV 1992
Resolve Comments & Finialize	1 APR 1992	30 NOV 1992
Additional Tests/Studies (1)	1 OCT 1992	31 MAR 1993
Prepare Annual TS Report #1.0	2 DEC 1991	9 MAR 1992
EPA/CDH Review	10 MAR 1992	10 APR 1992
Resolve Comments & Finalize	24 MAR 1992	10 APR 1992
Prepare Annual TS Report #2.0	1 DEC 1992	8 MAR 1993
EPA/CDH Review	9 MAR 1993	9 APR 1993
Resolve Comments & Finalize	23 MAR 1993	9 APR 1993



(1) All additional tests will be performed based on the findings from the Interim Reports on Treatability Studies performed.

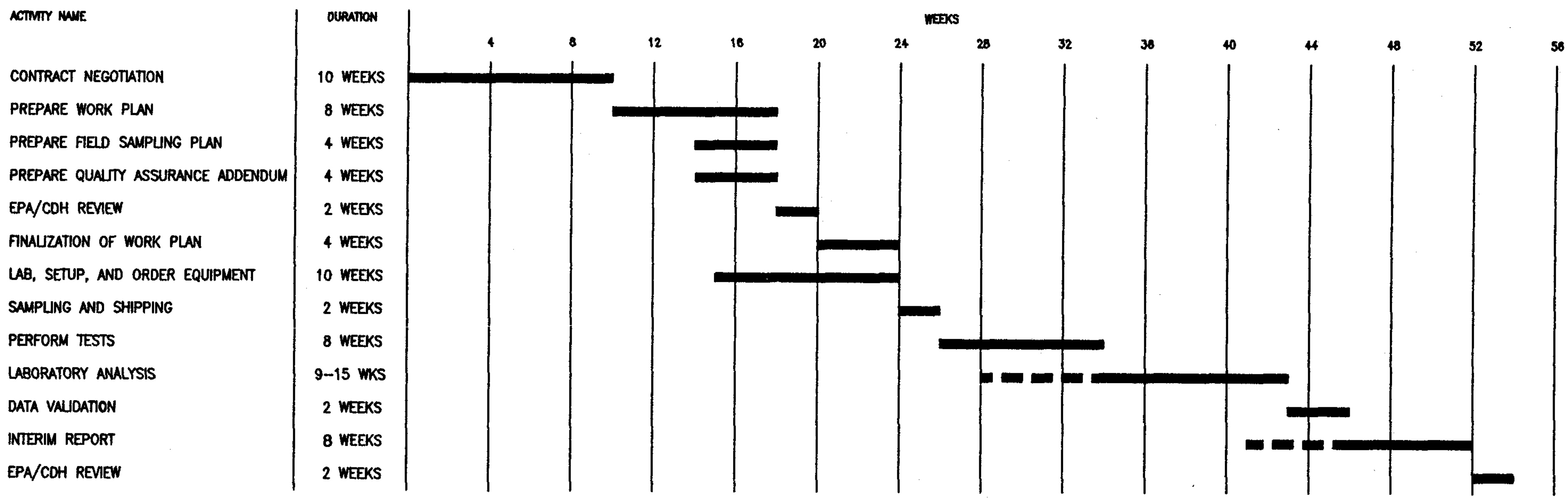
(2) The Treatability Study shall be initiated within 30 days of approval.

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY STUDIES PLAN

TENTATIVE
TREATABILITY STUDIES
PLAN SCHEDULE

FIGURE 7–1 MAY 1991



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY STUDIES PLAN

TENTATIVE SCHEDULE
FOR INDIVIDUAL TECHNOLOGY

FIGURE 7–2 MAY 1991

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8.0
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TABLE 4-1

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TABLE 5-1

GENERAL COMPARISON OF LABORATORY SCREENING, BENCH-SCALE TESTING, AND PILOT-SCALE TESTING

Tier	Type of Data Generated	Analytical Level[a]	Critical Parameters	Number of Replicates	Study Size	Usual Process Type	Waste Stream Volume	Time Required	Cost, $
Laboratory screening	Qualitative	I-II	Several	Single/ duplicate studies	Jar tests or beaker	Batch	Small	Hours/ days	10,000-50,000
Bench-scale testing	Semi-quantitative	III-V	Few	Duplicate/ triplicate	Bench-top (some larger)	Batch or continuous	Medium	Days/ weeks	50,000-250,000
Pilot-scale testing	Quantitative	III-V	Few	Triplicate/ or more	Pilot-plant (on-site or off-site)	Batch or continuous	Large	Weeks/ months	250,000-1,000,000

[a] Analytical levels are defined in Data Quality Objectives for Remedial Response Activities (U.S. EPA 1987b); see Subsection 6.2.3 and Table 6-1.

TABLE 5-2
LIST OF CHEMICALS REPORTED ABOVE ARARs IN TWO OR MORE OPERABLE UNITS

Contaminant	Operable Units (Two or More)			
	Reported in Groundwater	Reported in Surface Water	Reported in Soils	Reported in Sediments
METALS				
Aluminum		1, 2, 4, 5, 6, 7, USID		
Antimony		1, 2, 4, 6, LSID		
Arsenic	2, 4	4, BACK		
Barium		1, 4, 6, 7, USID, LSID		
Beryllium		1, 6, LSID	1, 2	1, 2, 5, LSID
Cadmium	1, 4	1, 4, 6, LSID		
Chromium	1, 2, 4, 7	1, 2, 4, 7, USED, LSID		
Iron	1, 2, 4	1, 2, 4, 5, 6, 7, LSID, USID		
Lead	2, 4	1, 2, 4, 5, 6, 7, LSID, USID		
Manganese	1, 2, 4, 7	1, 2, 4, 5, 6, 7, LSID, USID		
Mercury		1, 4, 6		
Nickel		4, 6, BACK		
Selenium	1, 2, 4, 7	1, 2, 4, 5, 6, 7, LSID		
INORGANICS				
Chloride	1, 4, 7	4, 7		
Nitrate and Nitrate + Nitrite	1, 2, 4, 7	1, 2, 4, 8		
Sulfate	1, 2, 4	4, 5, 7		
pH below minimum		1, 2, 4, 5, 6, 7, LSID, USID		

BACK = Sitewide Background Maximum
USID = Upper South Interceptor Ditch
LSID = Lower South Interceptor Ditch

TABLE 5-2
LIST OF CHEMICALS REPORTED ABOVE
ARARs IN TWO OR MORE OPERABLE UNITS
(Concluded)

Contaminant	Operable Units (Two or More)			
	Reported in Groundwater	Reported in Surface Water	Reported in Soils	Reported in Sediments
pH above maximum	2, 7	1, 4, 5, 7, LSID, USID		
Total Dissolved Solids	1, 2, 4, 7	1, 4, 5, 6, 7, 11, LSID		
RADIONUCLIDES				
Gross Alpha	1, 2, 4	1, 2, 4, 6, 7, LSID, USID	1, 2	1, 2
Gross Beta		1, 2, 4, 5, 6, 7, LSID, USID		
Plutonium 239 + 240		2, 4	1, 2	1, 2, 3
Radium 226		1, 4, 7, LSID, BACK		
Tritium		1, 2, 4, 5, 6, 8		
Uranium (Total)		1, 2, 4, 5, 6, 7, USID		
VOLATILE ORGANICS				
1,1-Dichloroethene	1, 2, 4	6, 7		
Carbon Tetrachloride	1, 2, 4, 6	2, 4		
Methylene Chloride	1, 2, 4, 7	1, 2, 7, LSID		
Tetrachloroethene	1, 2, 6, 7	1, 2, 4, 7		
Trichloroethene	1, 2, 4, 7	2, 4, 6, 7, LSID		
1,1,1-Trichloroethane	1, 2			
1,1,2-Trichloroethane	1, 2			
Vinyl Chloride	2, 4			

BACK = Sitewide Background Maximum
USID = Upper South Interceptor Ditch
LSID = Lower South Interceptor Ditch

TABLE 5-3A

POTENTIALLY APPLICABLE TECHNOLOGIES
GROUNDWATER AND SURFACE WATER

VOLATILE ORGANICS

PHYSICAL PROCESSES

Activated Carbon
Air Stripping
Distillation
Steam Stripping

CHEMICAL PROCESSES

Electron Beam
Gamma Irradiation
Oxidation by Hypochlorite
Ozonation
Peroxide Oxidation
Solar Photocatalytic
Ultraviolet Oxidation
Ultraviolet Photolysis

BIOLOGICAL

Anaerobic

THERMAL PROCESSES

Advanced Electric Reactor
Circulating Bed
Industrial Kiln/Furnace
Liquid Injection
Oxygen Enhanced Incinerator
Plasma Arc
Rotary Kiln
Submerged Quench
Supercritical Water Oxidation
Wet Air Oxidation

TABLE 5-3A

POTENTIALLY APPLICABLE TECHNOLOGIES GROUNDWATER AND SURFACE WATER (Continued)

SEMIVOLATILE ORGANICS

PHYSICAL PROCESSES

Activated Carbon	Solar Evaporation
Emulsion Liquid Membrane	Solvent Extraction
Freeze Crystallization	Steam Stripping

CHEMICAL PROCESSES

Catalytic Dechlorination	Ozonation
Chlorinolysis	Peroxide Oxidation
Electron Beam	Solar Photocatalytic
Gamma Irradiation	Supercritical Extraction
Hydrolysis	Ultraviolet Oxidation
MASX/MADS Process	Ultraviolet Photolysis
Oxidation by Hypochlorite	

BIOLOGICAL

Activated Sludge	Rotating Biological Disk
Aerated Lagoon	Sequence Batch Reactor
Anaerobic Digestion	Submerged Aerobic Fixed Film Reactor
In-Situ Bioremediation	Trickling Filter
Powdered Activated Carbon	White Rot Fungus

THERMAL PROCESSES

Advanced Electric Reactor	Rotary Kiln
Circulating Bed	Steam Stripping/Catalytic or Thermal Oxidation
Industrial Kiln/Furnace	Submerged Quench
Liquid Injection	Supercritical Water Oxidation
Oxygen Enhanced Incinerator	Wet Air Oxidation
Plasma Arc	

TABLE 5-3A

POTENTIALLY APPLICABLE TECHNOLOGIES
GROUNDWATER AND SURFACE WATER
(Continued)

INORGANICS

PHYSICAL PROCESSES

Adsorption	Freeze Crystallization
Electrodialysis	Ion Exchange
Emulsion Liquid Membrane Separation	Reverse Osmosis
Evaporation	Solar Distillation

CHEMICAL

Alkaline Chlorination	Oxidation/Reduction

METALS

PHYSICAL PROCESSES

Adsorption	Freeze Crystallization
Electrodialysis	Ion Exchange
Evaporation	Reverse Osmosis

CHEMICAL

Neutralization	Precipitation
Oxidation/Reduction	

BIOLOGICAL

Bioaccumulation

TABLE 5-3A

POTENTIALLY APPLICABLE TECHNOLOGIES
GROUNDWATER AND SURFACE WATER
(Concluded)

RADIONUCLIDES

PHYSICAL PROCESSES

Adsorption
Evaporation
Ion Exchange
Reverse Osmosis
Techtran, Inc. Process
Ultrafiltration/Microfiltration

CHEMICAL PROCESSES

Neutralization
Oxidation/Reduction
Precipitation
TRU/Clear™

BIOLOGICAL

Bioaccumulation

TABLE 5-3B

POTENTIALLY APPLICABLE TECHNOLOGIES
SOIL AND SEDIMENTS

VOLATILE ORGANICS

BIOLOGICAL PROCESSES

In-Situ Bioremediation	Slurry Reactor

PHYSICAL/CHEMICAL PROCESSES

Chemical Reduction - Oxidation	In-Situ Soil Flushing
Glycolate Dechlorination	Soil Washing
	Vacuum Extraction

THERMAL PROCESSES

AOSTRA TACIUK Process	Molten Salt/Sodium Fluxing
Fluidized Bed	Multiple Chamber Incinerator
HT-5 Thermal Distillation	Oxygen Enhanced Incinerator
High Temperature Fluid Wall	Plasma Arc
In-Situ Vacuum Extraction and Steam Injection	Radio-Frequency Heating
Indirect Heating	Rotary Kiln
Infrared Electric Furnace	Solar
Liquid Injection	Submerged Quench
Low Temperature Thermal Desorption	Supercritical Water Oxidation
Low Temperature Thermal Treatment	Vacuum Extraction/Catalytic Incineration
Molten Glass	Vacuum Extraction/Thermal Incineration
	Wet Air Oxidation

SEMIVOLATILE ORGANICS

BIOLOGICAL PROCESSES

Composting	Land Treatment
In-Situ Bioremediation	Slurry Reactor

TABLE 5-3B

POTENTIALLY APPLICABLE TECHNOLOGIES
SOIL AND SEDIMENTS
(Continued)

PHYSICAL/CHEMICAL PROCESSES

Chemical Reduction-Oxidation	Soil Washing
Glycolate Dechlorination	Solvent Extraction
In-Situ Electroacoustic Decontamination	Surfactants
In-Situ Soil Flushing	

THERMAL PROCESSES

AOSTRA TACIUK Process	Oxygen Enhanced Incinerator
Fluidized Bed	Plasma Arc
HT-5 Thermal Distillation	Radio-Frequency Heating
High Temperature Fluid Wall	Rotary Kiln
Indirect Heating	Solar
Infrared Electric Furnace	Submerged Quench
Liquid Injection	Supercritical Water Oxidation
Low Temperature Thermal Desorption	Vacuum Extraction and Steam Injection
Low Temperature Thermal Treatment	Vacuum Extraction/Catalytic Incineration
Molten Glass	Vacuum Extraction/Thermal Incineration
Molten Salt/Sodium Fluxing	Wet Air Oxidation
Multiple Chamber Incinerator	

SOLIDIFICATION/STABILIZATION

Asphalt	Polymerization - Epoxy
Glassification/Vitrification	Polymerization - Polyester
Gypsum Cement	Polymerization - Urea - Resin
In-Situ Vitrification	Portland Cement Process
Lime/Fly Ash Pozzolan Process	Sorption
Polymer Impregnated Concrete	

TABLE 5-3B

POTENTIALLY APPLICABLE TECHNOLOGIES
SOIL AND SEDIMENTS
(Continued)

INORGANICS

PHSYICAL/CHEMICAL PROCESSES

Soil Washing

METALS

PHYSICAL/CHEMICAL PROCESSES

Electrokinetic
In-Situ Electroacoustic Decontamination
In-Situ Soil Flushing
Physical Separation
Soil Washing

THERMAL PROCESSES

Molten Glass
Plasma Arc

SOLIDIFICATION/STABILIZATION

Asphalt
Asphalt-Based (Thermoplastic) Microencapsulation
Ceramic Encapsulation
"Cermet"
Electric Pyrolyzer
Glass-Ceramics
Glassification/Vitrification
Gypsum Cement
In-Situ Stabilization
In-Situ Vitrification
Lime/Fly Ash Pozzolan Process
Masonry Cement
Metal Matrices
Polymer Impregnated Concrete
Polymerization - Epoxy
Polymerization - Polyester
Polymerization - Urea - Resin
Polypropylene
Portland Cement Process
Pyro-disintegrator
Sorption
Sulfur Polymer Concrete
Wax

TABLE 5-3B

POTENTIALLY APPLICABLE TECHNOLOGIES
SOIL AND SEDIMENTS
(Concluded)

RADIONUCLIDES

PHYSICAL/CHEMICAL PROCESSES

Electrokinetic
In-Situ Soil Flushing
Magnetic Separation
Physical Separation
Soil Washing
TRU Clean™

THERMAL PROCESSES

Molten Glass
Plasma Arc

SOLIDIFICATION/STABILIZATION

Asphalt
Ceramic Encapsulation
"Cermet"
Glass-Ceramics
Glassification/Vitrification
Gypsum Cement
In-Situ Stabilization
In-Situ Vitrification
Lime/Fly Ash Pozzolan Process
Masonry Cement
Metal Matrices
Polymer Impregnated Concrete
Polymerization - Epoxy
Polymerization - Polyester
Polymerization - Polyethylene
Polymerization - Urea - Resin
Portland Cement Process
Sorption
Sulfur Polymer Concrete

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER

Contaminant Group: **Volatile Organics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Activated Carbon	Applicable to volatile compounds of low to moderate solubility in water	99+% achievable	Yes	Proven and commercially available	Low. Requires periodic replacement of GAC adsorbent.	Equipment available	Produces spent GAC solid waste stream which must be treated or disposed	Yes
Air Stripping	Applicable only to volatile compounds which have low solubility in water	95-99% achievable	Yes	Proven and commercially available	Low. Periodic cleaning of air stripper tower packing may be required.	Equipment available	Stripped organics are released to atmosphere if no exhaust controls are included	Yes
Distillation	Applicable to most volatile compounds including water soluble species	95-99% achievable	Yes	Proven and commercially available	Moderate. Scale build-up may be a problem. High energy use	Equipment available	Produces a concentrated organic product which must be treated or disposed by other means	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Steam Stripping	Applicable to most volatile compounds including water soluble species	95-99% achievable	Yes	Proven and commercially available	Moderate. Requires steam source.	Equipment available	A concentrated organic product is produced which must be treated or disposed by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Chemical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Electron Beam	Applicable to most volatile compounds including water soluble species	80-99% achievable. The presence of nitrates and carbonates interferes with removal efficiency.	Unknown	Innovative	Not well defined	Unknown. No commercial units available	May produce new radionuclides.	No[1]
Gamma Irradiation	Applicable to most volatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Innovative	Unknown	Equipment not currently commercially available	Toxic compounds from partial degradation may be formed	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Oxidation by Hypochlorite	Applicable to most volatile compounds including water soluble species. Not a specific treatment	High. Up to 99%	Low	Commercially available	Low. High chemical demand	Equipment available	Typically produces toxic trihalomethane by-products	No[1]
Ozonation	Applicable to most volatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific. Saturated chlorinated solvents not well removed	Medium to High	Proven and commercially available	High chemical demand	Equipment available	No significant adverse impacts	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Chemical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Peroxide Oxidation	Applicable to most volatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific. Saturated chlorinated solvents not well removed	Yes	Proven and commercially available	Low. High chemical demand	Equipment available	No significant impacts	Yes
Solar Photo-catalytic	Potentially applicable to most volatile organic compounds	Unknown	Unknown	Innovative	Unknown	Equipment not currently commercially available	Toxic compounds from partial degradation may be formed	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Ultraviolet Oxidation	Applicable to most volatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific. Saturated chlorinated solvents not well removed	Medium to High	Proven and commercially available	Low. Requires periodic maintenance of UV lamps. High power use	Equipment available	No significant adverse impacts	Yes
Ultraviolet Photolysis	Applicable to most volatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Commercially available	Low. High chemical demand	Equipment available	Potential for production of toxic by-products	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Biological**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Anaerobic	Higher strength organics	Variable. Efficiencies are compound-specific and can exceed 95%	Very site-specific	Developing. Some applications available	Low. May provide methane that can be used as energy source	Equipment rentals available. May require a polishing step. Process startup typically lengthy	Potential for odor formation. Sludge produced	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Thermal Processes**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Advanced Electric Reactor	Organic compounds in solids, sludges, liquids	High	Low	Commercial scale units available, but not proven	Requires source of nitrogen	Not applicable to water matrix	No major impacts identified	No[1]
Circulating Bed	Organic compounds in solids, sludges, slurries	High	Low	Commercial scale equipment available	Requires supplemental fuel	Not applicable to water matrix treated alone	No major impacts identified	No[1]
Industrial Kiln/ Furnace	Organic compounds in solids, sludges, slurries	High	Low	Commercial scale equipment available	Requires supplemental fuel	Not applicable to water matrix treated alone	No major impacts identified	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Thermal Processes**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Liquid Injection	Liquids with organic compounds	High	Low	Commercially available	High energy concentration to treat water matrix	Not applicable to water matrix	No major impacts identified	No[1]
Oxygen Enhanced Incinerator	Organic compounds in solids, sludges, liquids	High	Low	Commercial	High energy concentration to treat water matrix. Requires source of oxygen	Equipment available	No major impacts identified	No[1]
Plasma Arc	Liquids indirectly applicable to solids	High	Low	Commercial scale equipment available but unproven	High energy consumption per unit mass of organic; equipment not durable	Application to water matrix lowers throughput dramatically; small plumes of groundwater may be treated with soils	Potential products of incomplete combustion (PIC) production	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Thermal Processes**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Rotary Kiln	Organic compounds in solids, sludges, slurries	High	Low	Commercial scale equipment available	Requires supplemental fuel	Not applicable to water matrix treated alone	No major impacts identified	No[1]
Submerged Quench	Organic compounds in liquids and slurries	High	Low	Commercially available	Requires supplemental fuel and off-gas treatment	Not applicable to water matrix treated alone	No major impacts identified	No[1]
Supercritical Water Oxidation	Organic compounds in water	Moderate	Moderate	Commercially available	High energy consumption	Not applicable to organic concentrations in ppm range	No major impacts identified	Yes
Wet Air Oxidation	Organic compounds in water with COD > 15,000 mg/l	Moderate	Moderate	Commercial scale equipment available but unproven in dilute applications	High energy consumption	Not applicable to low concentrations	No major impacts identified	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Physical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Activated Carbon	Applicable to semi-volatile compounds of low to moderate solubility in water	99+% achievable	Yes	Proven and commercially available	Moderate to High. Requires periodic replacement of GAC adsorbent	Equipment available	Produces spent GAC waste stream which must be treated or disposed	Yes
Emulsion Liquid Membrane Separation	Potentially applicable to most volatile organic compounds	Unknown	Unknown	Innovative	Unknown	Equipment not commercially available	Unknown	No[1]
Freeze Crystallization	Applicable to dilute concentra-tions of semivolatile organics in water	High	Yes	Commercially available	Moderate. Requires high power use for refrigeration	Equipment commercially available	Produces concentrated waste stream which must be treated or disposed by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Solar Evaporation	Applicable to most semivolatile compounds including water soluble species	Moderate to high	Yes	Innovative	Low	Requires large area for evaporation pond. Capacity dependent on season and weather	A concentrated waste stream is produced which must be treated by other means of disposal	No[1]
Solvent Extraction	Applicable to most semivolatile compounds. Most applicable to moderate to high concentrations of contaminants	High at high initial concentrations of semivolatiles. Choice of solvents critical	Low to moderate	Commercially available	Moderate	Equipment commercially available	Produces a concentrated waste which must be treated or disposed by other means	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Steam Stripping	Applicable to most semivolatile compounds including water soluble species	95-99% achievable	Yes	Proven and commercially available	Moderate. Requires steam source	Equipment available	A concentrated waste stream is produced which must be treated by other means of disposal	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Catalytic Dechlorination	Applicable to semivolatile chlorinated compounds	Medium to high. Very compound-specific	Yes	Under development	Medium. Involves high pressure reaction with hydrogen gas	Equipment not currently commercially available	Unknown	Yes
Chlorinolysis	Applicable to most semivolatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Proven and commercially available	Moderate. High chemical demand. Operates at elevated pressures	Equipment available	Typically produces toxic trihalomethane by-products	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Electron Beam	Applicable to most semivolatile compounds including water soluble species	80-99% achievable. Subject to inteference by nitrates and carbonates.	Unknown	Innovative	Not well defined	Unknown. No commercial units available	Unknown. May produce new radionuclides.	No[1]
Gamma Irradiation	Applicable to most semivolatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Innovative	Unknown	Equipment not currently commercially available	Toxic compounds from partial degradation may be formed	Yes
Hydrolysis	Potentially applicable to most semi-volatile compounds	Unknown	Unknown	Innovative	Unknown	Unknown. No commercial units available	Unknown	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
MASX/MADS Solvent Extraction/ Distillation Stripping	Applicable to dilute concentrations of semivolatile organics in water	Unknown	Unknown	Innovative, untested	Unknown	Equipment not commercially available	Unknown	No[1]
Oxidation by Hypochlorite	Applicable to most semivolatile compounds including water soluble species	Medium to high. Very compound-specific	Yes	Commercially available	Moderate. High chemical demand	Equipment available	Typically produces toxic trihalomethanes as by-products	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Ozonation	Applicable to most semivolatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Commercially available	Low. High chemical demand	Equipment available	No significant adverse impacts	Yes
Peroxide Oxidation	Applicable to most semivolatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Proven and commercially available	Low. High chemical demand	Equipment available	No significant adverse impacts	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Chemical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Solar Photocatalytic	Potentially applicable to most volatile organic compounds	Unknown	Unknown	Innovative	Unknown	Equipment not commercially available	Unknown	No[1]
Supercritical Extraction	May be applicable	Unknown	Unknown	Innovative	Unknown	Equipment not commercially available	Unknown	No[1]
Ultraviolet Oxidation	Applicable to most semivolatile compounds including water soluble species. Not a specific treatment	Medium to high. Very compound-specific	Yes	Commercially available	Low. Requires periodic maintenance of UV lamps. High power use	Equipment available	No significant adverse impacts	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Chemical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Ultraviolet Photolysis	Applicable to most semivolatile compounds including water soluble species	Medium to high. Very compound-specific	Yes	Commercially available	Moderate. High power use	Equipment available	Potential for production of toxic by-products	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Biological

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Activated Sludge	Wide range of organics, including alcohols, phenols, cyanides, and ammonia in high concentrations	85 to 90%	Requires polishing step	Available	Low to moderate	Easily implemented	Produces waste sludge	No[1]
Aerated Lagoon	Wide range of organics	50 to 70%; may be seasonal	Low	Fully demonstrated	Low	Not difficult. Requires polishing step	Produces sludge	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Anaerobic Digestion	Organic acids, alcohols, sugars, chlorophenol in high concentrations	Variable efficiencies are compound-specific and can exceed 95%	Very site-specific	Demonstrated	Low. May produce methane that can be used as energy source	Equipment is readily available. May require a polishing step.	Produces sludge and off-gas. Potential for odor formation	No[1]
In-Situ Bioremediation	Wide range of organics	High efficiencies are achievable	Yes	Developing	Low	Requires careful design of extraction and reinjection wells	None	Yes
Powdered Activated Carbon	Handles a wide range of organics from low to high concentrations	Very high effectiveness (>99% is achievable)	High potential	Available	Moderate	Equipment is readily available	Produces waste carbon sludge that must be processed	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Biological**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Rotating Biological Disk	Alcohols, phenols, cyanides, ammonia in high concentrations	Up to 90%	Requires polishing step	Available	Low to moderate	Readily implemented	Produces waste sludge	No[1]
Sequence Batch Reactor	Primarily for nonhalogenated organics in low concentrations	70 to 85%	Low	Available	Moderate	Equipment is readily available. Needs polishing step	Produces sludge	No[1]
Submerged Aerobic Fixed Film Reactor	Wide range of organics in low to high concentrations	90 to 95%	Requires polishing step	Available	Low to moderate	Equipment readily available	Will produce sludge	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Biological**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Trickling Filter	Wide range of organics in concentrations above 50 ppm	Up to 90%	Requires polishing step	Available	Low	Readily implemented	Produces waste sludge	No[1]
White-rot Fungus	PCB, DDT, lindane, aromatics, chlorinated non-aromatics	Unknown	Unknown	Demonstrated on a lab scale only	Unknown	Supplements conventional biological treatment processes	Unknown	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Advanced Electric Reactor	Organic compounds in solids, sludges, liquids	High	Low	Commercial scale units available, not proven	Requires source of nitrogen	Not applicable to water matrix	No major impacts identified	No[1]
Circulating Bed	Organic compounds in solids, sludges, slurries	High	Low	Commercial scale equipment available	Requires supplemental fuel	Application to water matrix lowers throughput dramatically; small volumes of groundwater may be treated with soils	No major impacts identified	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Industrial Kiln/Furnace	Organic compounds in solids, sludges, slurries	High	Low	Commercial scale equipment available	Requires supplemental fuel	Application to water matrix lowers throughput dramatically; small volumes of groundwater may be treated with soils	No major impacts identified	No[1]
Liquid Injection	Liquids with organic compounds	High	Low	Commercially available	High energy consumption to treat water matrix	Not applicable to water matrix	No major impacts identified	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Oxygen Enhanced Incinerator	Organic compounds in solids, sludges, liquids	High	Low	Commercially available	High energy consumption to treat water matrix. Requires source of oxygen	Not applicable to water matrix	No major impacts identified	No[1]
Plasma Arc	Liquids indirectly applicable to solids	High	Low	Commercial scale equipment available but unproven	High energy consumption per unit mass of organic; equipment not durable	Application to water matrix lowers throughput dramatically; small volumes of groundwater may be treated with soils	Potential PIC production	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Rotary Kiln	Organic compounds in solids, sludges, slurries	High	Low	Commercial scale equipment available	Requires supplemental fuel	Application to water matrix lowers throughput dramatically; small volumes of groundwater may be treated with soils	No major impacts identified	No[1]
Steam and/or Vacuum Stripping/ Catalytic Oxidation/ Thermal Oxidation	Volatile and semivolatile organics in water	High, depending on solubility and vapor pressure of VOCs	High	Commercially available	Requires steam source	Equipment available; may require off-gas treatment	No major impacts identified	Yes
Submerged Quench	Organic compounds in liquids and slurries	High	Low	Commercially available	Requires supplemental fuel and off-gas treatment	Not applicable to water matrix treated alone	No major impacts identified	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Supercritical Water Oxidation	Organic compounds in water	Moderate	Moderate	Commercially available	High energy consumption	Not applicable to organic concentrations in ppm range	No major impacts identified	Yes
Wet Air Oxidation	Organic compounds in water with COD > 15,000 mg/l	Moderate	Moderate	Commercial scale equipment available but unproven in dilute applications	High energy consumption	Not applicable to low concentrations	No major impacts identified	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Inorganics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Adsorption	Applicable to many inorganics. Dependent on the contaminant and adsorbent identity	High	Yes	Commercially available	Low. Periodic replacement of adsorbent required	Equipment available	Produces a solid waste adsorbent which must be treated and disposed	Yes
Electrodialysis	Applicable to all dissolved ionic inorganic contaminants	Moderate to high. Depends on contaminant type and concentration	Yes	Commercially available	Membranes may require frequent cleaning	Equipment available	Produces a concentrated waste stream which must be treated and disposed by other means	Yes
Emulsion Liquid Membrane Separation	May be some potential for application to inorganics in water	Unknown	Unknown	Innovative, untested	Unknown	No commercial units available	Unknown	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Inorganics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Evaporation	Applicable to any non-volatile inorganics	High	Yes	Commercially available	Large energy use	Equipment available	Produces a concentrated waste stream which must be treated and disposed. Any volatile contaminants will remain with treated stream	Yes
Freeze Crystallization	Applicable to most dissolved and suspended inorganics	High	Yes	Commercially available	Moderate. Large energy use for refrigeration	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes
Ion Exchange	Applicable to dissolved ionic species	High	Yes	Commercially available	Moderate. Requires periodic regeneration of ion exchange resin	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Inorganics**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Reverse Osmosis	Applicable to most dissolved and suspended inorganics	Moderate to high. Depends on contaminant type and concentration	Yes	Commercially available	Operates at elevated pressure. Membranes may require frequent cleaning or replacement	Equipment available	Produces a concentrated waste stream which must be treated and disposed by other means	Yes
Solar Distillation	Applicable to non-volatile dissolved or suspended inorganics	High removal in overhead condensed water	Yes	Innovative	Low	Requires large area for solar evaporation pond. Volatile contaminants would evaporate with water	Produces a concentrated waste which must be treated and disposed by other means	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Inorganics**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Alkaline Chlorination	Applicable to destruction of cyanide	High for free cyanide. Low for some cyanide - metal complexes	Yes	Commercially available	Good process control	Equipment available	No significant	Yes
Oxidation/ Reduction	Applicable to cyanide and some metals including As, Fe, Cr, Mn - with metals, normally a precipitation and solids removal step follows	Moderate to high. Depends on species and subsequent treatment	Yes	Commercially available	Good process control	Equipment available	Sludge produced	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: Metals
Technology Group: Physical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Adsorption	Applicable to many metals. Dependent on the metal and adsorbent identities	High	Yes	Commercially available	Low. Periodic replacement of adsorbent required	Equipment available	Produces a concentrated waste which must be treated and disposed	Yes
Electrodialysis	Applicable to all dissolved ionic metals	Moderate to high. Depends on contaminant type and concentration	Yes	Commercially available	Membranes may require frequent cleaning	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes
Evaporation	Applicable to any non-volatile metals	High	Yes	Commercially available	Large energy use	Equipment available	Produces a concentrated waste stream which must be treated and disposed. Any volatile contaminants will remain with treated stream	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: Metals
Technology Group: Physical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Freeze Crystallization	Applicable to most dissolved and suspended metals	High	Yes	Commercially available	Moderate. Large energy use for refrigeration	Equipment available	Produces a concentrated waste stream which must be treated and disposed by other means	Yes
Ion Exchange	Applicable to dissolved ionic metals	High	Yes	Commercially available	Moderate. Requires periodic regeneration of ion exchange resin	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes
Reverse Osmosis	Applicable to most dissolved and suspended metals	Moderate to high. Depends on contaminant type and concentration	Yes	Commercially available	Operates at elevated pressure. Membranes may require frequent cleaning or replacement	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: Metals
Technology Group: Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Neutralization	Applicable to most metals as a pre- or post-treatment step	Moderate to high. Depends on metal and efficiency of suspended solids removal	Yes	Commercially available	Moderate. Good process control required	Equipment available	Produces a solid waste which must be treated and disposed of by other means	Yes
Oxidation/ Reduction	Applicable to metals which occur in varying oxidation states, including As, Fe, Cr, Mn. Normally must be followed by a pH adjustment, precipitation and suspended solids removal process.	Moderate to high. Depends on metal, pH, precipitating agent, and efficiency of solids removal	Yes	Commercially available	Moderate. Requires good process control	Equipment available	Produces a solid waste which must be treated and disposed by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Metals**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Precipitation	Applicable to most meals. Normally must be followed by a solids removal process	Moderate to high. Depends on metal, pH, precipitating agent, and efficiency of suspended solids removal	Yes	Commercially available	Moderate. Good process control required	Equipment available	Produces a solid waste which must be treated and disposed of by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Metals**
Technology Group: **Biological**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Bioaccumulation	Cd, Ag, Al, Cr, Co, Cu, Au, Fe, Pb, Mg, Mo, Ni, Zn, V	20 to 30%, although there have been some reports of 80%	Unknown	Under development	Unknown	Unknown. Will require a polishing step	Unknown	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Radionuclides**
Technology Group: **Physical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Adsorption	Applicable to many radionuclides. Dependent on the contaminant and adsorbent identity	High	Yes	Commercially available	Periodic replacement of adsorbent	Equipment available	Produces a solid waste adsorbent which must be treated and disposed	Yes
Evaporation	Applicable to any non-volatile radionuclide	High	Yes	Commercially available	Large energy use	Equipment available	Produces a concentrated waste which must be treated and disposed by other means. Any volatile contaminants will remain with treated stream	Yes
Ion Exchange	Applicable to dissolved ionic radionuclides	High	Yes	Commercially available	Ion exchange resin must be periodically regenerated or alternatively disposed	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Radionuclides**
Technology Group: **Physical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Reverse Osmosis	Applicable to most dissolved or suspended radionuclides	Moderate to high. Depends on contaminant type and concentration	Yes	Commercially available	Membranes may require frequent cleaning	Equipment available	Produces a concentrated waste which must be treated and disposed by other means	Yes
Techtran, Inc. Process	Radium, thorium and radium	Unknown	Unknown	Emerging. Recently introduced into EPA Site Program	Unknown	Special equipment not required	Produces solid wastes which must be treated or disposed	No[1]
Ultrafiltration/ Microfiltration	Applicable to any ionic radionuclides which can be effectively complexed with high molecular weight chelating agents	High if effective chelation occurs	Yes	Emerging	Filtration membranes require frequent cleaning or replacement	Equipment available	Produces some solid waste which must be treated and disposed	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Neutralization	Applicable to dissolved ionic radionuclides which form insoluble precipitates when pH is adjusted to neutral. Must be followed by a suspended solids removal step	Moderate to high. Dependent on solubility of precipitated metal and on suspended solids removal efficiency	Yes	Commercially available	Requires good process control	Equipment available	Produces a solid waste which must be treated and disposed	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Radionuclides**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Oxidation/ Reduction	Applicable to ionic radionuclides which occur in varying oxidation states such as Pu, U, Am. Normally, must be followed by a pH adjustment, precipitation, and suspended solids removal steps.	Moderate to high. Dependent on solubility of precipitated metal and on suspended solids removal efficiency	Yes	Commercially available	Requires good process control	Equipment available	Produces a solid waste which must be treated and disposed	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant Group: **Radionuclides**
Technology Group: **Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Precipitation	Applicable to dissolved ionic radionuclides which form insoluble compounds; must be followed by a suspended solids removal step	Moderate to high. Dependent on solubility of precipitated metal and on suspended solids removal efficiency	Yes	Commercially available	Requires good process control	Equipment available	Produces a solid waste which must be treated and disposed	Yes
TRU/Clear™	Applicable to dissolved ionic radionuclides in water.	Moderate to high	Yes	Demonstrated on a bench scale	Requires good process control	Uses standard equipment that is readily available	Produces a solid waste which must be treated and disposed	Yes

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4A
PRELIMINARY TECHNOLOGY SCREENING
GROUNDWATER AND SURFACE WATER
(Concluded)

Contaminant Group: **Radionuclides**
Technology Group: **Biological**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Bioaccumulation	Uranium	Unknown	Unknown	Emerging	Unknown	Unknown. Will require a polishing step	Unknown	No[1]

[1] See Table 5-6A for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS

Contaminant Group: Volatile Organics
Technology Group: Biological

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
In-Situ Bioremediation	Wide range of contaminants in low to high concentrations	High efficiency attainable under appropriate conditions but no demon-strated removal to less than 1 ppm	Low	Developing	Low	Requires careful design of extraction and reinjection wells	None	No[1]
Slurry Reactor	Wide range of contaminants in high concentrations	Varies with organic substrate	Moderate	Developing	High	Requires considerable materials handling	Produces liquid effluent	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Physical/Chemical**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Chemical Reduction-Oxidation	Sediments or slurried soils	Only partially effective	Low	Available	High. Extensive material handling required.	Equipment available	Produces liquid effluent	No[1]
Glycolate Dechlorination	PCBs or high concentrations of chlorinated organics	Variable	Unknown	Under development	High. Extensive material handling required.	Equipment available	Produces waste stream	No[1]
In-Situ Soil Flushing	Soil only	Unknown; very site specific	Unknown	Innovative	Moderate	Not easily implemented	Produces waste stream	No[1]
Soil Washing	Wide range of contaminants can be processed	Potentially very effective	Moderate to high	Available	High. Extensive material handling required.	Mobile equipment available - excavation required	Produces liquid effluent that may be toxic and contains the contaminants	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Volatile Organics
Technology Group: Physical/Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Vacuum Extraction	Soil only if volatile organic contamination is present	Very effective if concentrations are high	Moderate to high	Available	Moderate	Readily implemented in-situ	Produces off-gas that may require treatment	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING SOIL AND SEDIMENTS (Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
AOSTRA TACIUK Process	Volatile and semivolatile organics in soils	99.99% and above	High	Innovative; commercially available	Requires supplemental fuel	Equipment available	Recovers free product if contaminant is highly concentrated.	Yes
Fluidized Bed	Will handle wide range of VOCs	99.99% and above	High	Commercially available	Requires supplemental fuel	Requires off-gas treatment; mobile units available. Excavation required.	No major impacts	Yes
HT-5 Thermal Distillation Process	Volatile and semivolatile organics in soil	Unknown; depends on organics	Moderate	Innovative; demonstrated at pilot and full-scale	High; requires supplemental heat and cooling/refrigeration; requires makeup nitrogen	Requires bleed gas treatment	Recovers free product if contaminant is highly concentrated.	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Volatile Organics
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
High Temperature Fluid Wall	Organics and metals in dry, granular feed media; particularly stable organics	84.99% and above	Low	Innovative; commercial-size units available, but untested	High; feed must be ground to approximately 20-mesh; requires supplemental fuel	Requires off-gas treatment. Excavation required.	May produce leachable glass	No[1]
In-Situ Vacuum Extraction and Steam Injection	Volatile and semivolatile organics in soil	Unknown; depends on organics and soil matrix	High	Commercially available	Requires steam supply	Requires off-gas treatment	None known	Yes
Indirect Heating	Volatile organics in soils	Unknown; depends on VOCs and soil matrix	Low	Unproven	Unknown	Requires off-gas treatment; supplemental heat input	May leave residuals	No[1]
Infrared Electric Furnace	Applicable to VOCs and some semi-volatiles	99.99% and above	High	Commercially available	Requires supplemental fuel; moving parts in thermal zone	Requires after burner and off-gas treatment; mobile units available. Excavation required.	No major impacts.	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Liquid Injection	Liquids and atomizable slurries with low ash content	99.99% and above	Low	Commercial units available	Moderate; supplemental fuel required; requires nozzle maintenance	Requires off-gas treatment. Excavation required	No major impacts	No[1]
Low Temperature Thermal Desorption	Soil	Unknown	Low	Tested on pilot scale	Requires nitrogen supply	Requires off-gas treatment	May leave residuals	No[1]
Low Temperature Thermal Treatment	Soil	Unknown	High potential for very volatile organics	Available	Moderate to high	Requires off-gas treatment	May produce residuals	Yes
Molten Glass	Handles soils, sludges, liquids, VOCs, semivolatiles	99.99% and up	High	Commercially available	High-electrical consumption; refractory wear may require supplemental fuel	Requires off-gas treatment; may require after burner. Excavation required.	High-salt materials, may yield leachable glass	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Volatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Molten Salt/ Sodium Fluxing	Organics and metals in soils and sludges	99.99999% and above	High	Innovative; commercial-size units available	Requires supplemental heat input; make-up salt	Equipment available. Excavation required.	Produces salt; metals may leach; may increase waste volume	Yes
Multiple Chamber Incinerator	Organics in solid wastes	Unknown	High	Commercially available	Requires supplemental fuel	Requires off-gas treatment. Excavation required.	No major impacts	Yes
Oxygen Enhanced Incinerator	Organics, particularly polynuclear aromatics	99.99% and above	High	Commercial units available	May require supplemental fuel; requires supplemental oxygen	Requires off-gas treatment. Excavation required.	No major impacts	Yes
Plasma Arc	Atomizable liquids, solids, by indirect heating	99.9999% and up	Moderate	Innovative; available for small-scale applications	High; equipment not durable	Requires off-gas treatment. Excavation required.	PIC formation can be a problem	No[1]
Radio-Frequency Heating	Volatile and semivolatile organics in soil	94% and above	Moderate	Innovative; commercially available	Unknown	Requires off-gas treatment	May leave residuals	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Volatile Organics
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Rotary Kiln	Will handle wide range of VOCs	99.99% and above	High	Commercially available	Requires supplemental fuel	Requires off-gas treatment; mobile units available. Excavation required.	No major impacts	Yes
Solar	Organics in soils or other solid media	Unknown	Unknown	Innovative; proof of principle only	Unknown	Unknown. Excavation required.	Unknown	No[1]
Submerged Quench	Liquids and atomizable slurries containing suspended and dissolved solids with low fusion temperatures	99.99% and above	Low	Commercial units available	Moderate; supplemental fuels required; requires nozzle maintenance	Requires off-gas treatment. Excavation required.	Produces brine	No[1]
Supercritical Water Oxidation	Liquid wastes with high concentrations of organic contaminants	99.999% and above	Low	Commercially available	High; operates at >200 atm	Not recommended for wastes containing low ppm concentrations. Excavation required.	Produces salt; metals may leach	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Volatile Organics
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Vacuum Extraction/ Catalytic Incineration	Applicable to VOCs	Depends on compounds and matrix	Moderate to high	Commercial units available	May require supplemental heat input	Equipment readily available	Chlorinated solvents may corrode or poison catalyst	No[1]
Vacuum Extraction/ Thermal Incineration	Applicable to VOCs in high concentrations.	Depends on compounds and matrix	Moderate to high	Commercial units available	Requires supplemental fuel	Equipment readily available	None known	Yes
Wet Air Oxidation	Primarily applicable to sediments; requires high concentrations	Variable	Unknown	Pilot scale	Complex process; high temperature and pressure	Equipment not readily available	Produces off-gases and liquid effluent	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Biological

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Composting	Wide range of contaminants in high concentrations	Varies with organic substrate	Unknown	Demonstrated effective on municipal sludges	Low	Equipment readily available	Increased volume if organic additives used	No[1]
In-Situ Bioremediation	Wide range of contaminants in low to high concentrations	High efficiencies are attainable	Moderate to high	Developing	Low	Requires careful design of extraction and reinjection wells	None	Yes
Land Treatment	Pesticides, oils, halogenated solvents in high concentrations	Varies with organic substrate	Moderate to high	Available	Low	Not difficult to implement	Possible air emissions	Yes
Slurry Reactor	Wide range of contaminants in high concentrations	Varies with organic substrate	Moderate to high	Developing	High	Requires considerable materials handling	Produces liquid effluent	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING SOIL AND SEDIMENTS (Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Physical/Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Chemical Reduction-Oxidation	Sediments or slurried soils	Only partially effective	Low	Available	High	Requires extensive materials handling	Produces liquid effluent	No[1]
Glycolate Dechlorination	PCBs or highly concentrated chlorinated organics	Variable	Unknown	Under development	High	Equipment available	Produces waste stream	No[1]
In-Situ Electroacoustic Decontamination	Petroleum products	Low	Low	Emerging	High	Not readily implemented	Unknown	No[1]
In-Situ Soil Flushing	Requires permeable soils	Very compound and site specific	Unknown	Innovative	High	Requires careful design of extraction and injection wells	Flushing chemicals may cause environmental problems	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Physical/Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Soil Washing	Wide range of contaminants can be processed	Potentially very effective	High	Innovative	High	Mobile equipment available	Produces liquid effluent that contains the contaminant	Yes
Solvent Extraction	Wide range of organics in high concentrations	Up to 99% possible	High for high initial concentrations of semivolatiles	Available	Highly complex system	Requires specialized equipment	Produces waste extract	Yes
Surfactants	Pesticides, solvents, chlorinated hydrocarbons, waste oil and phenol	Unknown	Unknown	Innovative	Low to moderate	Supplements soil washing	Produces waste stream	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
AOSTRA TACIUK Process	Volatile and semivolatile organics in soils	99.99% and above	High	Innovative; commercially available	Requires supplemental fuel	Equipment available	Recovers free product	Yes
Fluidized Bed	Will handle wide range of organics	99.99% and above	High	Commercially available	Requires supplemental fuel	Requires off-gas treatment; mobile units available	No major impacts	Yes
HT-5 Thermal Distillation Process	Volatile and semivolatile organics in soil	Unknown; depends on organics	Moderate	Innovative; demonstrated at pilot and full-scale	High; requires supplemental heat and cooling/ refrigeration; requires makeup nitrogen	Requires bleed gas treatment	Recovers free product; may produce cited solids	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
High Temperature Fluid Wall	Organics and metals in dry, granular feed media; particularly stable organics	84.99% and above	Low	Innovative; commercial-size units available, but untested	High; feed must be ground to approximately 20-mesh; requires supplemental fuel; requires nitrogen supply	Requires off-gas treatment	May produce leachable glass	No[1]
Indirect Heating	Volatile organics in soils	Unknown; depends on VOCs and soil matrix	Low	Unproven	Unknown	Requires off-gas treatment; supplemental heat input	May leave residuals	No[1]
Infrared Electric Furnace	Applicable to wide range of organics	99.99% and above	High	Commercially available	Requires supplemental fuel; moving parts in thermal zone	Requires after burner and off-gas treatment; mobile units available	No major impacts	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Liquid Injection	Liquids and atomizable slurries with low ash content	99.99% and above	Low	Commercial	Moderate; supplemental fuel required; requires nozzle maintenance	Equipment available.	Produces off-gas that may require treatment.	No[1]
Low Temperature Thermal Desorption	Soil	Unknown	Low	Tested on pilot scale	Requires nitrogen supply	Requires off-gas treatment	May leave residuals	No[1]
Low Temperature Thermal Treatment	Soil	Unknown	Moderate to high	Available	Moderate to high	Requires off-gas treatment	May produce residuals	Yes
Molten Glass	Handles soils, sludges, liquids, VOCs, semivolatiles	99.99% and up	High	Commercially available	High electrical consumption; refractory wear; may require supplemental fuel	Requires off-gas treatment; may require after burner	High-salt materials may yield leachable glass	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Semivolatile Organics
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Molten Salt/Sodium Fluxing	Organics and metals in soils and sludges	99.99999% and above	High	Innovative; commercial-size units available	Requires supplemental heat input; make-up salt	Requires special equipment.	Produces salt; metals may leach; may increase waste volume	Yes
Multiple Chamber Incinerator	Organics in solid wastes	Unknown	High	Commercial	Requires supplemental fuel	Equipment is available	Requires off-gas treatment	Yes
Oxygen Enhanced Incinerator	Organics, particularly polynuclear aromatics	99.99% and above	High	Commercial	May require supplemental fuel; requires supplemental oxygen	Equipment available	Produces ash. May require off-gas treatment.	Yes
Plasma Arc	Atomizable liquid, solids by indirect heating	99.9999% and up	Low	Innovative; available for small-scale applications	High; equipment not durable	Requires off-gas treatment	PIC formation can be a problem	No[1]
Radio-Frequency Heating	Volatile and semivolatile organics in soil	94% and above	Moderate	Innovative; commercially available	Unknown	Requires off-gas treatment	May leave residuals	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING SOIL AND SEDIMENTS (Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Rotary Kiln	Will handle wide range of organics	99.99% and above	High	Commercially available	Requires supplemental fuel	Requires off-gas treatment; mobile units available	No major impacts	Yes
Solar	Organics in soils or other solid media	Unknown	Unknown	Innovative; proof of principle only	Unknown	Unknown	Unknown	No[1]
Submerged Quench	Liquids and atomizable slurries containing suspended and dissolved solids with low fusion temperatures	99.99% and above	Low	Commercial	Moderate; supplemental fuel required; requires nozzle maintenance	Equipment available	Produces brine. Requires off-gas treatment.	No[1]
Supercritical Water Oxidation	Liquid wastes with high concentrations of organic contaminants	99.999% and above	Low	Commercially available	High; operates at >200 atm	Not recommended for wastes containing low ppm concentrations	Produces salt; metals may leach	No[1]
Vacuum Extraction and Steam Injection	Volatile and semivolatile organics in soil	Unknown; depends on organics and soil matrix	Moderate to high	Commercially available	Requires steam supply	Requires off-gas treatment	May leave residuals	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Thermal Processes**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Vacuum Extraction/ Catalytic Incineration	Applicable to VOCs	Depends on compounds and matrix	Low	Commercial	May require supplemental heat input	Equipment available	May not remove certain semivolatiles effectively	No[1]
Vacuum Extraction/ Thermal Incineratation	Applicable to VOCs	Depends on compounds and matrix	Low	Commercial	Requires supplemental fuel	Equipment available	May not remove certain semivolatiles effectively	No[1]
Wet Air Oxidation	Primarily applicable to sediments; requires high concentrations	Variable	Unknown	Pilot scale	Complex process; high temperature and pressure	Equipment not readily available	Produces off-gases and liquid effluent	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Solidification/Stabilization**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Asphalt	Applies to wide range of contaminants	N/A*	N/A*	Available	Low	Would not be a problem to implement	Increased waste volume	Yes
Glassification/ Vitrification	Wide range of contaminants	N/A	N/A	Under development	High	Equipment not commercially available	Off-gas produced	Yes
Gypsum Cement	Wide range of contaminants	N/A	N/A	Demonstrated	Very high	Equipment available	Increased volume	No[1]
In-Situ Vitrification	Wide range of contaminants	N/A	N/A	Demonstrated	High	Equipment available	Off-gas treatment	Yes
Lime/Fly Ash Pozzolan Process	Site specific	N/A	N/A	Available	Low	Equipment readily available	Increased waste volume	Yes
Polymer Impregnated Concrete	Supplements other stabilization processes	N/A	N/A	Innovative	Unknown	Unknown	None	No[1]
Polymerization - Epoxy	Wide range of contaminants	N/A	N/A	Emerging	Unknown - probably high	Should not be difficult to implement	Increased waste volume	Yes
Polymerization - Polyester	Wide range of contaminants	N/A	N/A	Available	High	Equipment available	Increased waste volume	Yes

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Semivolatile Organics**
Technology Group: **Solidification/Stabilization**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Polymerization - Urea - Resin	Wide range of contaminants	N/A*	N/A*	Demonstrated	Unknown	Equipment available	Yields free water and corrosive liquids	No[1]
Portland Cement Process	Site specific	N/A	N/A	Available	Low	Equipment available	Increased waste volume	Yes
Sorption	Must be used in conjunction with other stabilization processes	N/A	N/A	Under development	Unknown	Cannot be used alone	Only physically stabilizes wastes	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Inorganics**
Technology Group: **Physical/Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Soil Washing	Wide range of contaminants can be processed	Potentially very effective	Yes	Innovative	High - requires extensive materials handling	Equipment required is available	Produces waste stream containing removal contaminants	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Physical/Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Electrokinetic	Potentially applicable to most metals	Unknown	Unknown	Innovative, lab demonstrated	Unknown	Equipment not commercial	Unknown	No[1]
In-Situ Electroacoustic Decontamination	Potentially applicable to most metals	Unknown	Unknown	Innovative	Unknown	Equipment not commercial	Unknown	No[1]
In-Situ Soil Flushing	Requires permeable soils	Very compound and site specific	Unknown	Innovative	High	Requires careful design of extraction and injection wells	Flushing chemicals may cause environ-mental problems	No[1]
Physical Separation	Used to reduce the volume of contaminated soil	N/A*	N/A*	Field tested for processing ores	High - requires extensive materials handling	Equipment required is available	Concentrated soil requires additional processing	Yes

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Physical/Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Soil Washing	Wide range of contaminants can be processed	Potential very effective	Yes	Innovative	High, requires extensive materials handling	Equipment required is available	Produces waste stream containing contaminants removed	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Molten Glass	Soils, sludges with organics and metals in high concentrations	High	High	Commercially available	High electrical consumption; refractory wear	May require off-gas treatment	May produce leachable glass	Yes
Plasma Arc	Atomizable liquids; solids by indirect heating	Unknown; depends on composition of matrix	Low	Innovative; available for small-scale applications	High; equipment not durable	Equipment not available for large-scale treatment of solids	May volatilize low - m.p. metals	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Solidification/Stabilization

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Asphalt	Applies to wide range of contaminants	N/A*	N/A*	Available	Low	Would not be difficult to implement	Increased waste volume	Yes
Asphalt-Based (Thermoplastic) Micro-encapsulation	Potentially applicable to wide range of contaminants	N/A	N/A	Available	High	Extensive materials handling equipment required	Potential for emission of volatile contaminants	Yes
Ceramic Encapsulation	High metal content	N/A	N/A	Emerging	High	Needs additional development	Increased volume	No[1]
"Cermet"	High metal content	N/A	N/A	Innovative	High	Needs additional development	Increased volume	No[1]
Electric Pyrolizer	Potentially applicable to wide range of contaminants	N/A	N/A	Emerging	High	Extensive materials handling equipment required	Potential for emission of volatile contaminants	No[1]
Glass-Ceramics	High metal content	N/A	N/A	Emerging	High	Needs additional development	Increased volume	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Solidification/Stabilization

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Glassification/ Vitrification	Wide range of contaminants	N/A*	N/A*	Demonstrated	Very high	Not easily implemented	Increased volume	Yes
Gypsum Cement	Wide range of contaminants	N/A	N/A	Demonstrated	Very high	Equipment available	Increased volume	No[1]
In-Situ Stabilization	Wide range of contaminants and concentrations	N/A	N/A	Commercially available	Not excessive	Readily implemented	None	Yes
In-Situ Vitrification	Wide range of contaminants	N/A	N/A	Demonstrated	High	Equipment available	Off-gas may need treatment	Yes
Lime/Fly Ash Pozzolan Process	Wide range of contaminants	N/A	N/A	Available	Moderate to high	Extensive materials handling equipment required	Increased volume	Yes
Masonry Cement	Low metal content	N/A	N/A	Demonstrated	High	Equipment available	Increased volume	Yes

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Solidification/Stabilization

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Metal Matrices	Primarily for radionuclide containment	N/A*	N/A*	Innovative	Very high	Equipment not yet available	Unknown	No[1]
Polymer Impregnated Concrete	Supplements other stabilization processes	N/A	N/A	Innovative	Unknown	Unknown	None	No[1]
Polymerization - Epoxy	Wide range of contaminants	N/A	N/A	Emerging	Unknown - probably high	Should not be difficult to implement	Increased waste volume	Yes
Polymerization - Polyester	Wide range of contaminants	N/A	N/A	Available	High	Equipment available	Increased waste volume	Yes
Polymerization - Urea - Resin	Wide range of contaminants	N/A	N/A	Demonstrated	Unknown	Equipment available	Yields free water and corrosive liquids	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Solidification/Stabilization

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Polypropylene	Potentially applicable to wide range of contaminants	N/A*	N/A*	Innovative	Unknown	Should not be difficult to implement	Increased waste volume	No[1]
Portland Cement Process	Wide range of contaminants	N/A	N/A	Available	Moderate	Equipment is available	Increased volume	Yes
Pyro-disintegrator	Potentially applicable to wide range of contaminants	N/A	N/A	Emerging	High	Extensive materials handling equipment required	Potential for emission of volatile contaminants	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Metals
Technology Group: Solidification/Stabilization

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Sorption	Must be used in conjunction with other stabilization processes	N/A*	N/A*	Under development	Unknown	Cannot be used alone	Only physically stabilizes wastes	No[1]
Sulfur Polymer Concrete	Wide range of contaminants	N/A	N/A	Innovative	Unknown	Unknown	Increased volume	No[1]
Wax	Used in conjunction with sorption	N/A	N/A	Innovative	Unknown	Should not be difficult to implement	Only physically stabilizes waste	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants. However, passing EP Tox or RCLP may achieve cleanup goals.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Radionuclides
Technology Group: Physical/Chemical

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Electrokinetic	Low level radionuclide concentrations	Unknown	Unknown	Innovative, lab demonstrated	Unknown	Equipment not commercial	Unknown	No[1]
In-Situ Soil Flushing	Requires permeable soils	Very compound and site specific	Unknown	Innovative	High	Requires careful design of extraction and injection wells	Flushing chemicals may cause environment-tal problems	No[1]
Magnetic Separation	Magnetic contaminants in coarse sizes	Effectively removes small amounts of contaminants from soil	Yes	Field tested	High. Requires extensive materials handling	Equipment is available	Concentrated waste requires further processing	Yes
Physical Separation	Used to reduce the volume of contaminated soil	N/A	N/A	Field tested for processing ores	High - requires extensive materials handling	Equipment required is available	Concentrated soil requires additional processing	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Radionuclides**
Technology Group: **Physical/Chemical**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Soil Washing	Wide range of contaminants can be processed	Potentially very effective	Yes	Innovative	High - requires extensive materials handling	Equipment is available	Produces waste stream containing removal contaminants	Yes
TRU Clean™	Transuranic (TRU) waste	Up to 98%	Yes	Emerging	High	Not commercially available	Concentrates plutonium in a water-moderated environment	Yes

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Radionuclides
Technology Group: Thermal Processes

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Molten Glass	Soils, sludges with organics and metals in high concentrations	High	High	Commercially available	High electrical consumption; refractory wear	May require off-gas treatment	May produce leachable glass	Yes
Plasma Arc	Atomizable liquids; solids by indirect heating	Unknown; depends on composition of matrix	Low	Innovative; available for small-scale applications	High; equipment not durable	Equipment not available for large-scale treatment of solids	May volatilize low - m.p. metals	No[1]

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: **Radionuclides**
Technology Group: **Solidification/Stabilization**

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Asphalt	Applies to wide range of contaminants	N/A*	N/A*	Available	Low	Would not be difficult to implement	Increased waste volume	Yes
Ceramic Encapsulation	High level radionuclides content	N/A	N/A	Emerging	High	Needs additional development	Increased volume	No[1]
"Cermet"	High level radionuclide content	N/A	N/A	Innovative	High	Needs additional development	Increased volume	No[1]
Glass-Ceramics	High level radionuclide content	N/A	N/A	Emerging	High	Needs additional development	Increased volume	No[1]
Glassification/ Vitrification	Wide range of contaminants	N/A	N/A	Demonstrated	High	Not easily implemented	Increased volume	Yes
Gypsum Cement	Wide range of contaminants	N/A	N/A	Demonstrated	Very high	Equipment available	Increased volume	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Continued)

Contaminant Group: Radionuclides
Technology Group: Solidification/Stabilization

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
In-Situ Stabilization	Wide range of contaminants and concentrations	N/A*	N/A*	Commercially available	Not excessive	Readily implemented	None	Yes
In-Situ Vitrification	Wide range of contaminants	N/A	N/A	Demonstrated	High	Equipment available	Off-gas may need treatment	Yes
Lime/Fly Ash Pozzolan Process	Wide range of contaminants	N/A	N/A	Available	Moderate to high	Extensive materials handling equipment required	Increased volume	Yes
Masonry Cement	Low level rad waste; boric acid	N/A	N/A	Demonstrated	High	Equipment available	Increased volume	Yes
Metal Matrices	Primarily for sediments	N/A	N/A	Innovative	Very high	Equipment not yet available	Unknown	No[1]
Polymer Impregnated Concrete	Supplements other stabilization processes	N/A	N/A	Innovative	Unknown	Unknown	None	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-4B

PRELIMINARY TECHNOLOGY SCREENING
SOIL AND SEDIMENTS
(Concluded)

Contaminant Group: **Radionuclides**
Technology Group: **Solidification/Stabilization**

Rocky Flats Plant
Sitewide Treatability Studies Plan

Technology	Applicability	Removal Efficiency	Potential to Meet Cleanup Goal	Technology Maturity	O&M Requirements	Implementability	Adverse Impacts	Retain Yes/No
Polymerization - Epoxy	Wide range of contaminants	N/A*	N/A*	Emerging	Unknown - probably high	Should not be difficult to implement	Increased waste volume	Yes
Polymerization - Polyester	Wide range of contaminants	N/A	N/A	Available	High	Equipment available	Increased waste volume	Yes
Polymerization - Polyethylene	Low level rad wastes	N/A	N/A	Emerging	Unknown	Unknown	Unknown	No[1]
Polymerization - Urea - Resin	Low level rad waste	N/A	N/A	Demonstrated	Unknown	Equipment available	Yields free water and corrosive liquids	No[1]
Portland Cement Process	Wide range of contaminants	N/A	N/A	Available	Moderate	Equipment is available	Increased volume	Yes
Sorption	Must be used in conjunction with other stabilization processes	N/A	N/A	Under development	Unknown	Cannot be used alone	Only physically stabilizes wastes	No[1]
Sulfur Polymer Concrete	Low level rad waste	N/A	N/A	Innovative	Unknown	Unknown	Increased volume	No[1]

* N/A refers to the fact that these technologies do not remove or destroy contaminants.

[1] See Table 5-6B for rejection rationale. Technologies that have not been retained are shaded.

TABLE 5-5A
GROUNDWATER/SURFACE WATER TREATMENT TECHNOLOGIES RETAINED AFTER PRELIMINARY SCREENING

Contaminant Group	Physical Treatments	Chemical Treatments	Biological Treatments	Thermal Treatments
Volatile Organics	Activated Carbon Air Stripping Steam Stripping	Gamma Irradiation Ozonation Peroxide Oxidation Ultraviolet Oxidation Ultraviolet Photolysis		Supercritical Water Oxidation
Semivolatile Organics	Activated Carbon Freeze Crystallization Steam Stripping	Catalytic Dechlorination Gamma Irradiation Ozonation Peroxide Oxidation Ultraviolet Oxidation Ultraviolet Photolysis	In-Situ Bioremediation Powdered Activated Carbon Submerged Aerobic Fixed Film Reactor	Steam Stripping/Catalytic or Thermal Oxidation Supercritical Water Oxidation
Inorganics	Adsorption Electrodialysis Evaporation Freeze Crystallization Ion Exchange Reverse Osmosis	Alkaline Chlorination Oxidation/Reduction		
Metals	Adsorption Electrodialysis Evaporation Freeze Crystallization Ion Exchange Reverse Osmosis	Neutralization Oxidation/Reduction Precipitation		
Radionuclides	Adsorption Evaporation Ion Exchange Reverse Osmosis Ultrafiltration/Microfiltration	Neutralization Oxidation/Reduction Precipitation TRU/Clear™		

TABLE 5-5B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES RETAINED AFTER PRELIMINARY SCREENING

Contaminant Group	Physical/Chemical Treatments	Biological Treatments	Thermal Treatments	Solidification/ Stabilization
Volatile Organics	Soil Washing		AOSTRA TACIUK Process	
			Fluidized Bed	
	Vacuum Extraction		Infrared Electric Furnace	
			Low Temperature Thermal Treatment	
			Molten Glass	
			Molten Salt/Sodium Fluxing	
			Multiple Chamber Incinerator	
			Oxygen Enhanced Incinerator	
			Radio-Frequency Heating	
			Rotary Kiln	
			Vacuum Extraction and Steam Injection	
			Vacuum Extraction/Thermal Oxidation	
Semivolatile Organics	Soil Washing	In-Situ Bioremediation	AOSTRA TACIUK Process	Asphalt
	Solvent Extraction	Land Treatment	Fluidized Bed	Glassification/Vitrification
			Infrared Electric Furnace	In-Situ Vitrification
			Low Temperature Thermal Treatment	Lime/Fly Ash Pozzolan
	Surfactants		Molten Glass	Polymerization-Epoxy
			Molten Salt/Sodium Fluxing	Polymerization-Polyester
			Multiple Chamber Incinerator	Portland Cement
			Oxygen Enhanced Incinerator	
			Radio-Frequency Heating	
			Rotary Kiln	
			Vacuum Extraction and Steam Injection	
Inorganics	Soil Washing			

TABLE 5-5B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES RETAINED AFTER PRELIMINARY SCREENING
(Concluded)

Contaminant Group	Physical/Chemical Treatments	Biological Treatments	Thermal Treatments	Solidification/ Stabilization
Metals	Physical Separation		Molten Glass	Asphalt
	Soil Washing			Asphalt Based (Thermoplastic) Microencapsulation
				Glassification/Vitrification
				In-Situ Stabilization
				In-Situ Vitrification
				Lime-Fly Ash Pozzolan
				Masonry Cement
				Polymerization-Epoxy
				Polymerization-Polyester
				Portland Cement
Radionuclides	Magnetic Separation		Molten Glass	Asphalt
	Physical Separation			Glassification/Vitrification
	Soil Washing			In-Situ Stabilization
	TRU Clean™			In-Situ Vitrification
				Lime/Fly Ash Pozzolan
				Masonry Cement
				Polymerization-Epoxy
				Polymerization-Polyester
				Portland Cement

TABLE 5-6A

GROUNDWATER/SURFACE WATER TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING

Technology	Reason Rejected from Further Consideration at This Time
Volatile Organics - Physical Treatments	
Distillation	Produces liquid waste; less suitable than other proven technologies. Equipment is very expensive and requires high energy usage.
Volatile Organics- Chemical Treatments	
Electron Beam	Undefined O&M requirements and implementability; potential for formation of undesirable by-products; inadequate data has been developed on this technology to date.
Oxidation by Hypochlorite	Leads to formation of toxic trihalomethane by-products.
Solar Photocatalytic	Unknown effectiveness and undefined O&M requirements and implementability; potential for formation of undesirable by-products; inadequate data has been developed on this technology to date.
Volatile Organics - Biological Treatments	
Anaerobic	Possible low removal efficiencies with questionable ability to meet clean-up goals; produces a waste sludge.
Volatile Organics - Thermal Treatments	
Advanced Electric Reactor	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.
Circulating Bed	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.
Industrial Kiln/Furnace	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.

TABLE 5-6A

GROUNDWATER/SURFACE WATER TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING (Continued)

Technology	Reason Rejected from Further Consideration at This Time
Liquid Injection	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.
Oxygen Enhanced Incineration	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.
Plasma Arc	Low potential to meet clean-up goals; potential for production of PICs.
Rotary Kiln	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.
Submerged Quench	Low potential to meet clean-up goals; unsuitable for treatment of water matrix containing low concentrations of contaminants.
Wet Air Oxidation	Only moderate potential to meet clean-up goals; not applicable to water containing dilute concentrations of organics.
<u>Semivolatile Organics - Physical Treatments</u>	
Emulsion Liquid Membrane Separation	Unknown effectiveness and ability to meet clean-up goals; questionable implementability; inadequate data has been developed on this technology to date.
Solar Evaporation	Not implementable at site due to need for large evaporation ponds; produces a liquid waste.
Solar Extraction	Low potential to meet cleanup goals; produces a liquid waste.

TABLE 5-6A

GROUNDWATER/SURFACE WATER TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING (Continued)

Technology	Reason Rejected from Further Consideration at This Time
Semivolatile Organics - Chemical Treatments	
Chlorinolysis	Produces toxic trihalomethane by-products.
Electron Beam	Undefined O&M requirements and implementability; potential for formation of undesirable by-products; inadequate data has been developed on this technology to date.
Hydrolysis	Unknown effectiveness and ability to meet cleanup goals; questionable implementability; inadequate data has been developed on this technology to date.
MASX/MADS Solvent Extraction/Distillation Stripping	Unknown effectiveness and ability to meet clean-up goals; questionable implementability; inadequate data has been developed on this technology to date.
Oxidation by Hypochlorite	Leads to formation of toxic trihalomethane by-products.
Solar Photocatalytic	Unknown effectiveness and ability to meet clean-up goals; questionable implementability; inadequate data has been developed on this technology to date.
Supercritical Extraction	Unknown effectiveness and ability to meet clean-up goals; questionable implementability.; inadequate data has been developed on this technology to date
Semivolatile Organics - Biological Treatments	
Activated Sludge	Inability to meet cleanup goals; produces waste sludge.
Aerated Lagoon Reactor	Low potential to meet cleanup goals; produces waste sludge.

TABLE 5-6A

GROUNDWATER/SURFACE WATER TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING (Continued)

Technology	Reason Rejected from Further Consideration at This Time
Anaerobic Digestion	Inability to meet cleanup goals; produces waste sludge.
Rotating Biological Disk	Inability to meet cleanup goals; produces waste sludge.
Sequence Batch Reactor	Inability to meet cleanup goals; produces waste sludge.
Trickling Filter	Inability to meet cleanup goals; produces waste sludge.
White-rot Fungus	Unknown ability to meet cleanup goals; inadequate data has been developed on this technology to date.
<u>Semivolatile Organics - Thermal Treatments</u>	
Advanced Electric Reactor	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.
Circulating Bed	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.
Industrial Kiln/Furnace	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.
Liquid Injection	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.
Oxygen Enhanced Incineration	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.
Plasma Arc	Low potential to meet clean-up goals; potential for production of PICs.
Rotary Kiln	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.

TABLE 5-6A

GROUNDWATER/SURFACE WATER TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING (Concluded)

Technology	Reason Rejected from Further Consideration at This Time
Submerged Quench	Low potential to meet clean-up goals; unsuitable for treatment of water matrix with low concentrations of contaminants.
Wet Air Oxidation	Only moderate potential to meet clean-up goals; not applicable to water containing dilute concentrations of organics.
<u>Inorganics - Physical Treatments</u>	
Emulsion Liquid Membrane Separation	Unknown potential to meet cleanup goals; unknown O&M requirements and problems with implementability; inadequate data has been developed on this technology to date.
Solar Distillation	Not implementable at site, requires construction of large evaporation ponds.
<u>Metals - Biological Treatments</u>	
Bioaccumulation	Unknown potential to meet cleanup goals; unknown O&M requirements and implementability.
<u>Radionuclides - Physical Treatments</u>	
Techtran, Inc., Process	Unknown potential to meet cleanup goals; unknown O&M requirements and implementability.
<u>Radionuclides - Biological Treatments</u>	
Bioaccumulation	Unknown potential to meet cleanup goals; unknown O&M requirements and implementability.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING

Technology	Reason Rejected From Further Consideration at This Time
Volatile Organics - Biological Treatments	
In-Situ Bioremediation	Low potential to meet cleanup goal.
Slurry Reactor	Most suitable for high organic concentrations; produces liquid waste. Excavation and extensive materials handling required.
Volatile Organics - Physical/Chemical Treatments	
Chemical Reduction-Oxidation	Low potential to achieve cleanup goals; produces liquid waste.
Glycolate Dechlorination	Suitable for PCBs; unknown ability to achieve cleanup goals; produces liquid waste stream.
In-Situ Soil Flushing	Unknown effectiveness; produces liquid waste; inadequate data has been developed on this technology to date.
Volatile Organics - Thermal Treatments	
HT-5 Thermal Distillation Process	Unknown effectiveness; high O&M requirements; inadequate data has been developed on this technology to date.
High Temperature Fluid Wall	Low potential to meet cleanup goals; extensive O&M requirements.
Indirect Heating	Low potential to meet cleanup goals; may leave residuals.
Liquid Injection	Applicable to concentrated soil washing solutions only.
Low Temperature Thermal Desorption	Low potential to meet cleanup goals; may leave residuals.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING
(Continued)

Technology	Reason Rejected From Further Consideration at This Time
Plasma Arc	Low potential to meet cleanup goals; PIC formation a potential problem.
Solar	Unknown potential to achieve cleanup goals; inadequate data has been developed on this technology to date.
Submerged Quench	Low potential to meet cleanup goals; produces liquid brine water.
Supercritical Water Oxidation	Low potential to meet cleanup goals; suitable for wastes with high organic concentrations.
Vapor Extraction/Catalytic Incineration	Catalytic incineration not suitable for chlorinated solvents.
Wet Air Oxidation	Suitable for wastes with high organic concentrations; questionable ability to meet cleanup goals; produces off-gas and liquid waste.
<u>Semivolatile Organics - Biological Treatments</u>	
Composting	Most suitable for waste with high organic concentrations; questionable ability to meet cleanup goals; may increase total waste volume.
Slurry Reactor	Most suitable for waste with high organic concentrations; extensive materials handling required; produces liquid waste.
<u>Semivolatile Organics - Physical/Chemical Treatments</u>	
Chemical Reduction-Oxidation	Low effectiveness and low potential to meet cleanup goals; high O&M requirements with extensive materials handling.
Glycolate Dechlorination	Suitable for high concentrations of PCBs or chlorinated compounds; questionable ability to meet cleanup goals; produces liquid waste.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING
(Continued)

Technology	Reason Rejected From Further Consideration at This Time
In-Situ Electroacoustic Decontamination	Low effectiveness and low potential to meet cleanup goals; high O&M requirements; problems with implementability.
In-Situ Soil Flushing	Unknown potential to meet cleanup goals; may produce environmental problems; inadequate data has been developed on this technology to date.
<u>Semivolatile Organics - Thermal Treatments</u>	
HT-5 Thermal Distillation Process	Unknown effectiveness; high O&M requirements; inadequate data has been developed on this technology to date.
High Temperature Fluid Wall	Low potential to meet cleanup goals; extensive O&M requirements.
Indirect Heating	Low potential to meet cleanup goals; may leave residuals.
Liquid Injection	Low potential to meet cleanup goals; suitable for dilute suspensions of solids from soil washing operations only.
Low Temperature Thermal Desorption	Low potential to meet cleanup goals; may leave residuals.
Plasma Arc	Low potential to meet cleanup goals; potential for PIC production.
Solar	Unknown effectiveness; undefined O&M requirements and problems with implementability; inadequate data has been developed on this technology to date.
Submerged Quench	Low potential to meet cleanup goals; suitable for dilute suspensions of solids.
Supercritical Water Oxidation	Most suitable for waste with high organic concentrations; low potential to meet cleanup goals; produces waste salt.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING
(Continued)

Technology	Reason Rejected From Further Consideration at This Time
Vacuum Extraction/Catalytic Incineration	Vacuum extraction suitable for organic compounds with significant vapor pressures; low potential to meet cleanup goals; chlorinated compounds may poison catalyst.
Vacuum Extraction/Thermal Incineration	Vacuum extraction suitable for organic compounds with significant vapor pressures; low potential to meet cleanup goals.
Wet Air Oxidation	Suitable for wastes with high organic concentrations; questionable ability to meet cleanup goals; produces off-gas and liquid waste.
<u>Semivolatile Organics - Solidification/Stabilization Treatments</u>	
Gypsum Cement	Very high O&M requirements; increases waste volume.
Polymerization - Urea - Resin	Yields corrosive liquids.
Polymer Impregnated Concrete	Must be applied in conjunction with other stabilization processes; inadequate data has been developed on this technology to date.
Sorption	Not effective without application of other stabilization processes.
<u>Metals - Physical/Chemical Treatments</u>	
Electrokinetic	Unknown effectiveness and ability to meet cleanup goals; problems with implementability; inadequate data has been developed on this technology to date.
In-Situ Electroacoustic Decontamination	Unknown effectiveness and ability to meet cleanup goals; problems with implementability; inadequate data has been developed on this technology to date.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING
(Continued)

Technology	Reason Rejected From Further Consideration at This Time
In-Situ Soil Flushing	Questionable ability to meet cleanup goals; may produce environmental problems
<u>Metals - Thermal Treatments</u>	
Plasma Arc	Low potential to meet cleanup goals; problems with implementability; may volatilize some metals.
<u>Metals - Solidification/Stabilization Treatments</u>	
Ceramic Encapsulation	Suitable for waste with high metal content; high O&M requirements; increases waste volume; inadequate data has been developed on this technology to date.
"Cermet"	Suitable for waste with high metal content; high O&M requirements; increases waste volume; inadequate data has been developed on this technology to date.
Electric Pyrolizer	High O&M requirements with extensive materials handling; may produce emissions.
Glass-Ceramics	Suitable for waste with high metal content; high O&M requirements; increases waste volume; inadequate data has been developed on this technology to date.
Gypsum Cement	Very high O&M requirements; increases waste volume.
Metal Matrices	Primarily suited to radionuclide containment; very high O&M requirements; inadequate data has been developed on this technology to date.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING
(Continued)

Technology	Reason Rejected From Further Consideration at This Time
Polymer Impregnated Concrete	Must be applied in conjunction with other stabilization processes; inadequate data has been developed on this technology to date.
Polymerization - Urea - Resin	Yields corrosive liquids.
Polypropylene	Unknown problems with O&M; inadequate data has been developed on this technology to date.
Pyro-disintegrator	High O&M requirements with extensive materials handling; may produce emissions.
Sorption	Not effective without application of other stabilization processes.
Sulfur Polymer Concrete	Unknown O&M and implementation issues; inadequate data has been developed on this technology to date.
Wax	Must be applied in conjunction with other stabilization processes; inadequate data has been developed on this technology to date.
<u>Radionuclides - Physical/Chemical Treatments</u>	
Electrokinetic	Unknown effectiveness and ability to meet cleanup goals; problems with implementability; inadequate data has been developed on this technology to date.
In-Situ Soil Flushing	High O&M requirements; may cause environmental problems.

TABLE 5-6B
SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING
(Continued)

Technology	Reason Rejected From Further Consideration at This Time
<u>Radionuclides - Thermal Treatments</u>	
Plasma Arc	Low potential to meet cleanup goals; problems with implementability; may volatilize some radionuclides.
<u>Radionuclides - Solidification/Stabilization Treatments</u>	
Ceramic Encapsulation	Suitable for waste with high radionuclide content; high O&M requirements; increases waste volume; inadequate data has been developed on this technology to date.
"Cermet"	Suitable for waste with high radionuclide content; high O&M requirements; increases waste volume; inadequate data has been developed on this technology to date.
Glass-Ceramics	Suitable for waste with high radionuclide content; high O&M; inadequate data has been developed on this technology to date.
Gypsum Cement	Very high O&M requirements; increases waste volume.
Metal Matrices	Very high O&M requirements; problems with implementability; inadequate data has been developed on this technology to date.
Polymer Impregnated Concrete	Must be applied in conjunction with other stabilization processes; inadequate data has been developed on this technology to date.
Polymerization Polyethylene	Unknown problems with O&M; inadequate data has been developed on this technology to date.
Polymerization - Urea - Resin	Yields corrosive liquids.

TABLE 5-6B

SOIL/SEDIMENT TREATMENT TECHNOLOGIES NOT PASSING PRELIMINARY SCREENING (Concluded)

Technology	Reason Rejected From Further Consideration at This Time
Sorption	Not effective without application of other stabilization processes.
Sulfur Polymer Concrete	Unknown O&M and implementation issues; inadequate data has been developed on this technology to date.

TABLE 5-7A
SITEWIDE TREATABILITY TEST PROGRAM
SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED
GROUNDWATER AND SURFACE WATER

Contaminant: Volatiles

Technology	Additional Data from Laboratory, Bench or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Activated Carbon	No	Yes	Yes	No	Yes	No problems expected	No
Air Stripping	No	Yes	No	No	Yes	Potential problems	No
Gamma Irradiation	Yes	No	No	No	No	No problems expected	No
Ozonation	Yes	Yes	No	No	Yes	No problems expected	Yes
Peroxide Oxidation	Yes	Yes	No	No	Yes	No problems expected	Yes
Steam Stripping	No	No	No	No	Yes	No problems expected	No
Supercritical Water Oxidation	Yes	No	No	No	Yes	Problems expected	No
Ultraviolet Oxidation	Yes	Yes	No	No	Yes	No problems expected	Yes
Ultraviolet Photolysis	Yes	Yes	No	No	Yes	No problems expected	Yes

* Includes one or more advantages pertaining to cost effectiveness, O&M requirements, or fewer adverse impacts relative to applicable technologies that do not require testing.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7A
SITEWIDE TREATABILITY TEST PROGRAM
SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant: Inorganics

Technology	Additional Data from Laboratory, Bench or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Adsorption	No	Yes	Yes	No	Yes	No problems expected	No
Alkaline Chlorination	No	No	Yes	No	Yes	No problems expected	No
Electrodialysis	No	Yes	No	No	Yes	No problems expected	No
Evaporation	No	Yes	No	No	Yes	No problems expected	No
Freeze Crystallization	No	Yes	Yes	No	Yes	No problems expected	No
Ion Exchange	No	Yes	Yes	No	Yes	No problems expected	No
Oxidation/ Reduction	No	No	Yes	No	Yes	No problems expected	No
Reverse Osmosis	No	Yes	Yes	No	Yes	No problems expected	No

* Includes one or more advantages pertaining to cost effectiveness, O&M requirements, or fewer adverse impacts relative to applicable technologies that do not require testing.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7A
SITEWIDE TREATABILITY TEST PROGRAM
SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED
GROUNDWATER AND SURFACE WATER
(Continued)

Contaminant: Metals

Technology	Additional Data from Laboratory, Bench or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Adsorption	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Electrodialysis	No	Yes	No	No	Yes	No problems expected	No
Evaporation	No	No	No	No	Yes	No problems expected	No
Freeze Crystallization	No	Yes	Yes	No	Yes	No problems expected	No
Ion Exchange	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Neutralization	No	Yes	Yes	No	Yes	No problems expected	No
Oxidation/ Reduction	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Precipitation	No	Yes	Yes	No	Yes	No problems expected	No
Reverse Osmosis	No	Yes	Yes	No	Yes	No problems expected	No

* Includes one or more advantages pertaining to cost effectiveness, O&M requirements, or fewer adverse impacts relative to applicable technologies that do not require testing.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7A
SITEWIDE TREATABILITY TEST PROGRAM
SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED
GROUNDWATER AND SURFACE WATER
(Concluded)

Contaminant: Radionuclides

Technology	Additional Data from Laboratory, Bench or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Adsorption	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Evaporation	No	No	No	No	Yes	No problems expected	No
Ion Exchange	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Neutralization	No	Yes	Yes	No	Yes	No problems expected	No
Oxidation/ Reduction	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Precipitation	No	Yes	Yes	No	Yes	No problems expected	No
Reverse Osmosis	No	Yes	Yes	No	Yes	No problems expected	No
TRU/Clear™	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Ultrafiltration/ Microfiltration	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes

* Includes one or more advantages pertaining to cost effectiveness, O&M requirements, or fewer adverse impacts relative to applicable technologies that do not require testing.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7B
SITEWIDE TREATABILITY TEST PROGRAM SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED - SOIL AND SEDIMENTS

Contaminant: Metals

Technology	Additional Data from Laboratory, Bench, or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Asphalt Based (Thermoplastic) Microencapsulation	Yes	No	Yes	No	Yes	No problems expected	No
Asphalt Stabilization	Yes	No	Yes	No	Yes	No problems expected	No
Glassification/ Vitrification	Yes	Yes	No	No	Yes	Potential problems	No
In-Situ Stabilization	Yes	Yes	No	No	Yes	Potential problems	No
In-Situ Vitrification	Yes	Yes	No	No	Yes	Potential problems	No
Lime/Fly Ash Pozzoian Process	Yes	No	Yes	No	Yes	No problems expected	No
Masonry Cement	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Molten Glass Incineration	Yes	Yes	No	No	No	Potential problems	No
Physical Separation	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes

* Includes one or more advantages pertaining to cost, effectiveness, O&M requirements, or fewer adverse impacts.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7B
SITEWIDE TREATABILITY TEST PROGRAM SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED - SOIL AND SEDIMENTS
(Continued)

Contaminant: Metals

Technology	Additional Data from Laboratory, Bench, or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Polymerization - Epoxy	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Polymerization - Polyester	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Portland Cement Stabilization	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Soil Washing	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes

* Includes one or more advantages pertaining to cost, effectiveness, O&M requirements, or fewer adverse impacts.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7B
SITEWIDE TREATABILITY TEST PROGRAM SELECTION MATRIX FOR TECHNOLOGIES TO BE TESTED - SOIL AND SEDIMENTS
(Continued)

Contaminant: Radionuclides

Technology	Additional Data from Laboratory, Bench, or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Asphalt Stabilization	Yes	No	Yes	No	Yes	No problems expected	No
Glassification/ Vitrification	Yes	Yes	No	No	Yes	Potential problems	No
In-Situ Stabilization	Yes	Yes	No	No	Yes	No problems expected	Yes
In-Situ Vitrification	Yes	Yes	No	No	Yes	Potential problems	No
Lime/Fly Ash Pozzolan Process	Yes	No	Yes	No	Yes	No problems expected	No
Magnetic Separation	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Masonry Cement	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Molten Glass Incineration	Yes	Yes	No	No	No	Potential problems	No
Physical Separation	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes

* Includes one or more advantages pertaining to cost, effectiveness, O&M requirements, or fewer adverse impacts.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-7B
SITEWIDE TREATABILITY TEST PROGRAM SELECTION MATRIX
FOR TECHNOLOGIES TO BE TESTED - SOIL AND SEDIMENTS
(Concluded)

Contaminant: Radionuclides

Technology	Additional Data from Laboratory, Bench, or Pilot Bench Testing Needed for Selection	Offers Advantages over Other Available Technologies*	Amenable to Testing at Bench/Lab Scale	Test at Bench/Lab Scale	Amenable to Testing at Pilot Scale	Anticipated EPA, State, and/or Community Acceptance	Test** at Pilot Scale
Polymerization - Epoxy	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Polymerization - Polyester	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Portland Cement Stabilization	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
Soil Washing	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes
TRU Clean™	Yes	Yes	Yes	Yes	Yes	No problems expected	Yes

* Includes one or more advantages pertaining to cost, effectiveness, O&M requirements, or fewer adverse impacts.

** Need for pilot testing will be reviewed in annual reports. Review will be based on results achieved during bench/lab tests (if conducted) and an additional review of site characterization, ARARs, technology data, cost of pilot testing and full scale implementation, and EPA/CDH input.

TABLE 5-8

TECHNOLOGIES SELECTED FOR BENCH OR LABORATORY SCALE TREATABILITY STUDIES*

Groundwater and Surface Water			Appendix B Page Number for Technology Data Sheet
Adsorption	for	Metals/Radionuclides	B-1.1
Ion Exchange	for	Metals/Radionuclides	B-1.8
Oxidation/Reduction	for	Metals/Radionuclides	B-1.13
TRU/Clear™	for	Radionuclides	B-1.28
Ultrafiltration/ Microfiltration	for	Radionuclides	B-1.30
Soil and Sediments			
Physical Separation	for	Metals/Radionuclides	B-1.17
Polymerization Stabilization-Epoxy	for	Metals/Radionuclides	B-1.23
Polymerization Stabilization-Polyester	for	Metals/Radionuclides	B-1.23
Portland Cement Stabilization	for	Metals/Radionuclides	B-1.23
Soil Washing	for	Metals/Radionuclides	B-1.20
Magnetic Separation	for	Radionuclides	B-1.10
Masonry Cement Stabilization	for	Metals/Radionuclides	B-1.23
TRU Clean™	for	Radionuclides	B-1.27

* Additional review will be conducted after completion of bench and laboratory tests to determine if pilot testing should be conducted.

TABLE 5-9

TECHNOLOGIES IDENTIFIED FOR PILOT SCALE TREATABILITY STUDIES*

Groundwater and Surface Water			Appendix B Page Number for Technology Data Sheet
Ozonation	for	Volatile Organics	B-1.4
Peroxide Oxidation	for	Volatile Organics	B-1.4
Ultraviolet Oxidation	for	Volatile Organics	B-1.4
Ultraviolet Photolysis	for	Volatile Organics	B-1.32

* Additional review of site characterization data, ARARs, technology data, costs of pilot testing and full scale implementation of technologies, and input from CDH/EPA will be conducted to determine if pilot testing is required.

TABLE 6-1
SUMMARY OF ANALYTICAL LEVELS[a]

	Level I
Type of analysis	Field screening or analysis with portable instruments.
Limitations	Usually not compound-specific, but results are available in real time. Not quantifiable.
Data quality	Can provide an indication of contamination presence. Few QA/QC requirements.
	Level II
Type of analysis	Field analyses with more sophisticated portable instruments or mobile laboratory. Organics by GC, inorganics by AA, ICP, or XRF.
Limitations	Detection limits vary from low parts per million to low parts per billion. Tentative identification of compounds. Techniques/instruments limited mostly to volatile organics and metals.
Data quality	Depends on QA/QC steps employed. Data typically reported in concentration ranges.
	Level III
Type of analysis	Organics/inorganics performed in an off-site analytical laboratory. May or may not use CLP procedures. Laboratory may or may not be a CLP laboratory.
Limitations	Tentative compound identification in some cases.
Data quality	Detection limits similar to CLP. Rigorous QA/QC.
	Level IV
Type of analysis	Hazardous Substances List (HSL) organics/inorganics by GC/MS, AA, ICP. Low parts-per-billion detection limits.
Limitations	Tentative identification of non-HSL parameters. Validation of laboratory results may take several weeks.
Data quality	Goal is data of known quality. Rigorous QA/QC.
	Level V
Type of analysis	Analysis by nonstandard methods.
Limitations	May require method development or modification. Method-specific detection limits. Will probably require special lead time.
Data quality	Method-specific.

[a]Source: EPA, 1987a (modified).

TABLE 6-2

SUGGESTED ORGANIZATION OF THE TREATABILITY STUDIES PROGRAM INTERIM REPORTS[1]

1. Introduction
   - 1.1 Site description
     - 1.1.1 Site name and location
     - 1.1.2 History of operations
     - 1.1.3 Prior removal and remediation activities
   - 1.2 Waste stream description
     - 1.2.1 Waste matrices
     - 1.2.2 Pollutants/chemical
   - 1.3 Remedial technology description
     - 1.3.1 Treatment process and scale
     - 1.3.2 Operating features
   - 1.4 Previous treatability studies at the site

2. Conclusions and Recommendations
   - 2.1 Conclusions
   - 2.2 Recommendations

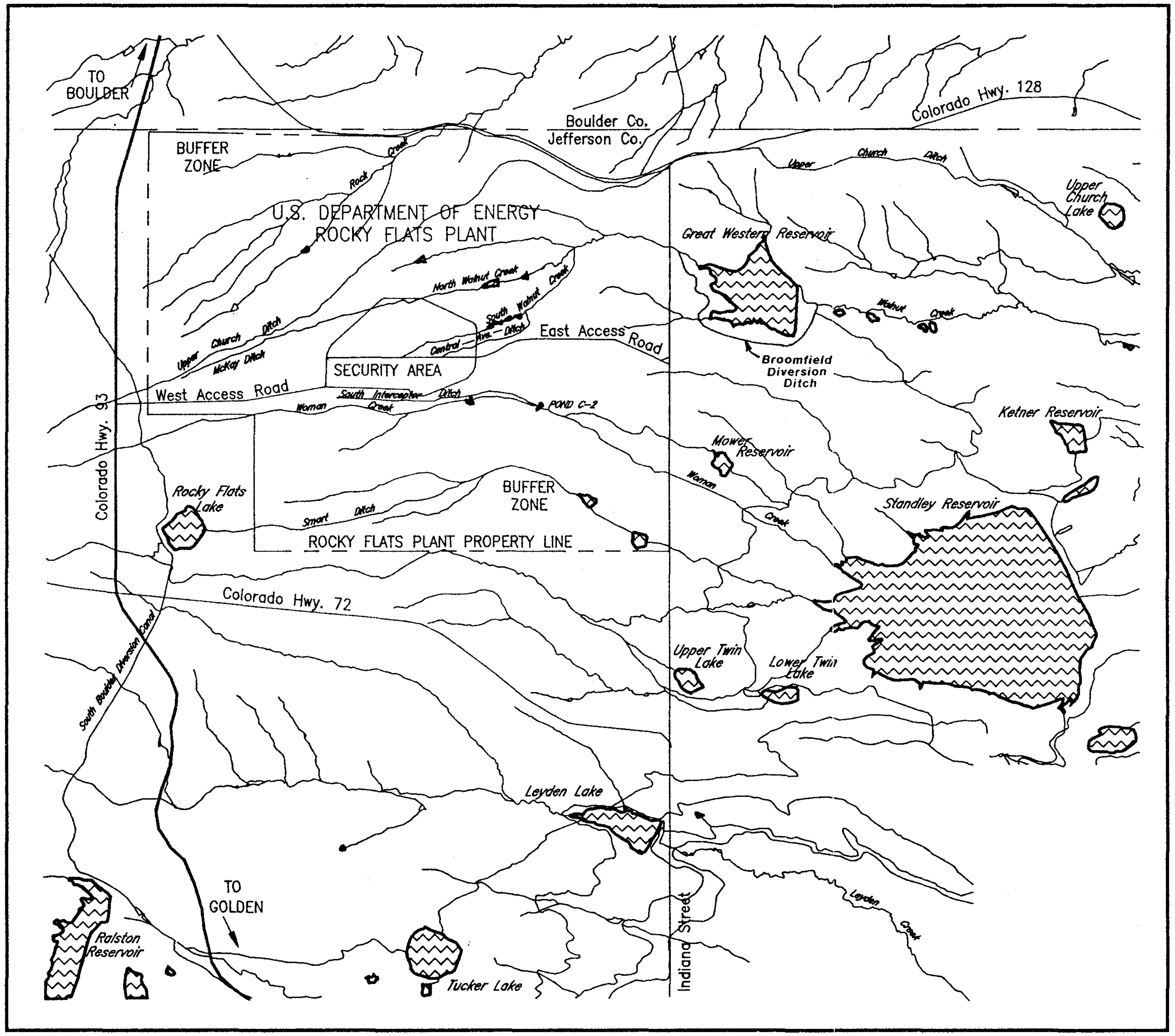
3. Treatability Study Approach
   - 3.1 Test objectives and rationale
   - 3.2 Experimental design and procedures
   - 3.3 Equipment and materials
     - 3.4.1 Waste stream
     - 3.4.2 Treatment process
   - 3.5 Data management
   - 3.6 Deviations from the work plan

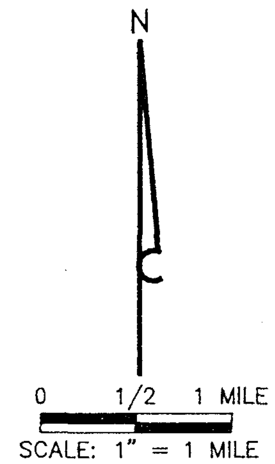
4. Results and Discussion
   - 4.1 Data analysis and interpretation
     - 4.1.1 Analysis of waste stream characteristics
     - 4.1.2 Analysis of treatability study data
     - 4.1.3 Comparison to test objectives
     - 4.1.4 Characterization and management of general waste
   - 4.2 Quality assurance/quality control
   - 4.3 Costs/schedule for performing the treatability study
   - 4.4 Key contacts

References

Appendices
   - A. Data summaries
   - B. Standard operating procedures

[1] EPA Guide for Conducting Treatability Studies Under CERCLA (U.S. EPA 1989b)





EXPLANATION

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

FINAL TREATABILITY
STUDIES PLAN

ROCKY FLATS PLANT
BOUNDARIES AND BUFFER ZONE

FIGURE 2-2 MAY 1991

25060022

TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**

Parameter	Groundwater (mg/L)			Surface Water (mg/L)			Soils (mg/kg)			Sediments (mg/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
METALS (TOTAL AND DISSOLVED)												
Aluminum	4.75 BR (B)	0.200	5.0	293 (A)	0.200	0.200	70600 (B)	40		24800 (A)	40	
Antimony	0.208 (E)	0.060	0.01	0.416 (A)	0.060	0.146	39.6 (G)	12	3000	42.1 (A)	12	3000
Arsenic	1.6 J BR (B)	0.010	0.05	1.03 (A)	0.010	0.05	37 (B)	2		13 (A)	2	
Barium	0.9321 (B)	0.200	1.0	87.6 (E)	0.200	1.0	1899 (B)	40	4000	300 (A)	40	4000
Beryllium	0.029 (E)	0.005	0.1	0.09 (E)	0.005	0.005	15.5 (C)	1.0	0.143	15.5 (A)	1.0	0.143
Cadmium	0.0352 BR (F)	0.005	0.01	25 (A)	0.005	0.01	27.4 (G)	1.0		2.3 (C)(E)	1.0	
Calcium	1900 BR (F)	5.000		51200 (E)	5.000		312000 (E)	2000		132000 (C)	2000	
Cesium	0.4 (G)	1.000		12 (A)	1.000		274 (C)	200				
Chromium	0.172 BR (F)	0.010	0.05	0.298 (A)	0.010	0.05	58 (C)	2.0	400 (VI)	43.38 (C)	2.0	400 (VI)
Cobalt	0.14 (E)	0.050	0.05	0.489 (A)	0.050		36 BR (E)	10		12 (C)	10	
Copper	0.9515 (E)	0.025	1.0	0.908 (E)	0.025	1.0	30.62 (C)	5.0		40.4 (A)	5.0	
Iron	57.1 (F)	0.100	0.3	3220 (A)	0.100	0.30	67200 BR (E)	20		33300 (A)	20	
Lead	0.21 J BR (B)	0.005	0.05	0.516 (A)	0.005	0.050	45.6 (C)	1.0		66.4 (A)	1.0	
Lithium	0.7 (E)	0.100		85.2 (A)	0.100		47 (E)	20		27.8 (C)(E)	20	
Magnesium	788 (F)	5.000		7540 (E)	5.000		6490 BR (E)	2000		5970 (A)	2000	
Manganese	6 (F)	0.015	0.05	27.7 (A)	0.015	0.050	3540 (C)	3.0		1390 (A)	3.0	
Mercury	0.006 (E)	0.0002	0.002	3.97 (E)	0.0002	0.002	114 (C)	0.2		0.72 (C)	0.2	
Molybdenum	1.92 BR (B)	0.200		0.333 (A)	0.200		38.65 (C)	40		42 (E)	40	
Nickel	11.7 (E)	0.040	0.2	0.646 (A)	0.040	0.1	71 BR (E)	8.0	2000	34 (C)	8.0	2000
Potassium	633 BR (F)	5.000		4260 (A)	5.000		4440 (G)	2000		67000 (E)	2000	
Selenium	3.2 (E)	0.005	0.010	0.55 (A)	0.005	0.010	1.5 (C)	1.0		21.3 (A)	1.0	
Silicon	10.7 (F)											

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(a) = Plutonium 238+239+240
(b) = Radium 226+228

TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**
(Continued)

Parameter	Groundwater (mg/L)			Surface Water (mg/L)			Soils (mg/kg)			Sediments (mg/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
METALS (TOTAL AND DISSOLVED) (Continued)												
Silver	0.13 (B)	0.010	0.050	0.148 (A)	0.010	0.050	40.9 (C)	2.0	200	49.1 (A)	2.0	200
Sodium	924 (F)	5.000		17300 (E)	5.000		3680 (C)	2000		670 (E)	2000	
Strontium	7.7 BR (B)	0.200		11.9 (A)	0.200		226 (C)	40		179 (E)	40	
Thallium	0.016 (E)	0.050								13 (E)	2.0	
Tin	1.121 (E)	0.200		1.53 (A)	0.200		33.8 (C)	40		1080 (A)	40	
Vanadium	0.092 BR (B)	0.050		1.65 (A)	0.050		108 (C)	10		58.4 (C)	10	
Zinc	4.39 BR (F)	0.020	5.0	28.7 (E)	0.020	5.0	195 (G)	4.0		735 (C)	4.0	

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TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES
(Continued)**

Parameter	Groundwater (mg/L)			Surface Water (mg/L)			Soils (mg/kg)			Sediments (mg/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
ANIONS												
Bicarbonate as $CaCO_3$	1100 (F)	10		1900 (A)	10							
Carbonate as $CaCO_3$	505 BR (B)	10		270 (A)	10							
Chloride	960 BR (F)	5	250	960 (A)	5	250						
Cyanide	10.2 (E)	10	10	21 J (E)	10	10	6.8 (E)					
Fluoride	1.7 (G)	5	5									
Nitrate as N	15.5 (C)	5	10	18593 (A)	5	10	4.3 (C)			35.86 (A)		
Nitrate + Nitrite as N	5000 (F)	5	10	9900 (A)	5	10	180 (G)			13 (A)		
Nitrite as N				24 (A)	5	5						
Sulfate	1900 (F)	5	250	1900 (E)	5	250						
Sulfide				120 (A)			13 (C)	4				

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(a) = Plutonium 238+239+240
(b) = Radium 226+228

TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES** (Continued)

Parameter	Groundwater (mg/L)			Surface Water (mg/L)			Soils (mg/kg)			Sediments (mg/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
INDICATORS												
Conductivity Min. (umho/cm)				73.7 (A)	1							
Conductivity Max. (umho/cm)				37120 (A)	1							
Dissolved Oxygen (mg/L)												
Minimum				0 (A)								
Maximum				70 (A)	0.5							
Oil and Grease	6.7 (G)			321 (G)	5					2200 (A)		
Percent Solids (%)												
Minimum							78.9 (G)			14.7 (A)		
Maximum							96.4 (G)			96.4 (A)		
pH minimum (pH units)	5.98 (C)	0.1	6.5	3.4 (A)	0.1	6.5	5.65 (E)			6.1 (A)		
pH maximum (pH units)	12 (F)	0.1	8.5	10.2 (A)	0.1	8.5	10.14 (C)			9.03 (C)		
Temperature (degrees C)												
Minimum				2 (A)								
Maximum				33 (A)								
Total Dissolved Solids (mg/L)	22000 (F)	10	500	41000 (A)	10	500						
Total Suspended Solids (mg/L)	1800 (F)	5		7600 (A)	5							

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(a) = Plutonium 238 + 239 + 240
(b) = Radium 226 + 228

TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**
(Continued)

Parameter	Groundwater (pCi/L)			Surface Water (pCi/L)			Soils (pCi/g)			Sediments (pCi/g)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
RADIONUCLIDES (TOTAL AND DISSOLVED)												
Americium 241	2.3 (E)	0.01		90 (A)	0.01	30	2273 (B)	0.02		0.04 (E)	0.02	
Cesium 137	3.1 (E)	1		25 (E)	1		3.1 (B)	0.1		3.2 (A)	0.1	
Gross Alpha	811 BR (E)	2	15	1900 (A)	2	15	480 (B)	4	5	77 (A)	4	5
Gross Beta	368 (F)	4	50	3800 (A)	4	5	49.9 (G)	10	50	50 (C)	10	50
Plutonium 239 + 240	4.6 (G)	0.01	15(a)	120 (A)	0.01	15(a)	20455 (B)	0.03	0.9	3.3 (A)	0.03	0.9
Radium 226	0.8 (E)(G)	0.5		30 (A)	0.5	5(b)	1.6 (G)	0.5		1.3 (C)	0.5	
Radium 228				24 (A)	0.5	5(b)	2.6 (G)	0.5		2.3 (A)	0.5	
Strontium 89 + 90	4.59 (G)	1.0		37 (C)	1.0		1.9 (E)	1		0.5 (C)	1	
Strontium 90	5.7 (G)	1.0	8	3.2 (A)	1.0	8	1.41 (G)	1		0.99 (A)	1	
Tritium	7710 (F)	400	20000	13000 (A)	400	500	3260 (G)	400		580 (E)	400	
Uranium 233 + 234	723 (G)	0.6		861 (A)	0.6		60 (E)	0.3		2.1 (A)	0.3	
Uranium 235	9 (F)	0.6		65.5 (A)	0.6		1.01 (G)	0.3		1.34 (A)	0.3	
Uranium 235 + 236	0.009 (G)	0.6		1.192 (G)	0.6							
Uranium 238	190 (F)	0.6		366 (A)	0.6		3000 (E)	0.3		2.7 (C)(A)(E)	0.3	
Uranium (Total)	63.7 (B)	0.6		1023 (A)	0.6	5	4 BR (E)	0.3		4.8 (E)	0.3	

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(a) = Plutonium 238+239+240
(b) = Radium 226+228

TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**
(Continued)

Parameter	Groundwater (ug/L)			Surface Water (ug/L)			Soils (ug/kg)			Sediments (ug/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
VOLATILES												
1,1-Dichloroethane	344 (E)	5		50 (A)	5		32 (C)	5				
1,1-Dichloroethene	48000 (E)	5	7	143 (C)	5	7	110 (C) *	5	12000			
1,1,1-Trichloroethane	30250 (E)	5	200	42 (C)	5	200	250 (B)	5	7000000			
1,1,2-Trichloroethane	14740 (E)	5	28				62 (C)	5	120000			
1,1,2,2-Tetrachloroethane				440 (G)	5							
1,2-Dichloroethane	16000 (E)	5	5				120 (B)	5	7700			
1,2-Dichloroethene (Total)	5070 (E)	5	70	56 (C)	5	70	140 (C)	5				
1,2-Dichloropropane	5 (F)	5	5									
1,3-Dichloropropene							6 J (C)	5	3900			
2-Butanone	110 (G)	10		24 (E) *	10		390 (E)	10		12 (C)	10	
2-Chloroethylvinylether							31 J (B)	10				
2-Hexanone	975 (B)	10										
4-Methyl-2-Pentanone	35 (B)	10		15 (A)	10		68 BR (E)	10		220 (E) *	10	
Acetone	1300 (B)	10	4000	180 (A)	10	4000	2400 (C) *	10	8000000	220 (E)	10	8000000
Benzene	83 J (E)	5	5	83 (A)	5	5						
Bromodichloromethane				2 J (C)	5							
Bromomethane	7 J (G)											
Carbon Disulfide	21 (G)	5		19 (A)	5		40 (G)			6 J (E)	5	
Carbon Tetrachloride	28000 (E)	5	5	1005 (C)	5	5	180 (C)*	5	5400			
Chlorobenzene				94 (A)	5	100	150 (C)	55				

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(a) = Plutonium 238+239+240
(b) = Radium 226+228

TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**
(Continued)

Parameter	Groundwater (ug/L)			Surface Water (ug/L)			Soils (ug/kg)			Sediments (ug/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
VOLATILES (Continued)												
Chloroethane	17 (F)	10		20 (A)	10		50 J (B)	10				
Chloroform	5427 (B)	5	100	82 (A)	5	100	130 J (B)	5	110000	18 (C)	5	110000
Chloromethane	4J (G)			12.5 (A)	10					60 (E)	10	
Ethylbenzene	6 (E)	5	680	12.5 (A)	5	1400	780 (B)	5	8000000	1 J (C)	5	8000000
Methylene Chloride	1500 (E) *	5	5	44 (C)	5	5	590 BR (E)	5	93000	22 (E)	5	93000
Styrene	9 (B)	5					17 J (B)	5				
Tetrachloroethene	528000 (B)	5	10	280 (A)	5	5	10000 (B)	5	140000	8 (C)	5	140000
Toluene	270 J (E) *	5	2420	12 (E)	5	14300	640 (B)	5	20000000	6 J (E)	5	20000000
Trichloroethene	221860 (B)	5	5	2500 (C)	5	5	17000 (B)	5	64000	39 (C)	5	64000
Vinyl Acetate	39 J (E)											
Vinyl Chloride	930 (B)	10	10	25 (A)	10	10				5 J (C)	10	
Xylenes (Total)	4 J (B)	5	7000	13 (A)	5	7000	3300 (B)	5	200000000	7 J (C)	5	200000000

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TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**
(Continued)

Parameter	Groundwater (ug/L)			Surface Water (ug/L)			Soils (ug/kg)			Sediments (ug/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
SEMIVOLATILES (TOTAL, UG/L)												
Acenaphthene							57 J (E)	330				
Anthracene							81 J (E)	330				
Benzo (a) Anthracene							110 J (E)	330	224			
Benzo (b) Fluoranthene							89 J (E)	330				
Benzo (k) Fluoranthene							280 J (E)	330				
Benzo (g,h,i) Perylene							50 J (E)	330				
Benzo (k) Pyrene							130 J (E)	330				
Bis (2-ethylhexyl) Phthalate	100 J BR (D)	10	10	220 (A)	10	15000	8700 (C) *	330	83000			
Chrysene							91 J (E)	330				
Diethyl Phthalate							29 (E)	330	60000000			
Di-n-Butyl Phthalate	170 J BR (D)	10	4.0				3643 (E)	330	8000000			
Di-n-Octyl Phthalate	56 J BR (D)	10					265 (E)	330				
Fluoranthene							290 J (E)	330				
Fluorene							350 (E)	330				
Indeno (1,2,3-cd) Pyrene							47 (E)	330				
2-Methylnaphthalene				15 (A)	10							
2-Methylphenol				43 (A)	10							
N-Nitrosodiphenylamine	100 J BR (D)	10					370 (B) *	330				
Phenanthrene							370 (E)	330				

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TABLE 4-2

ANALYTE CONCENTRATIONS FOR COMBINED OPERABLE UNITS 1-8, 10-14, AND 16 AND UPPER AND LOWER SOUTH INTERCEPTOR DITCHES**
(Concluded)

Parameter	Groundwater (ug/L)			Surface Water (ug/L)			Soils (ug/kg)			Sediments (ug/kg)		
	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential ARAR	Maximum+	Minimum++	Potential*** ARAR	Maximum+	Minimum++	Potential*** ARAR
SEMI-VOLATILES (TOTAL, UG/L) (Continued)												
Phenol				18 (A)	10	3500						
Pyrene							270 J (E)	330				

REFERENCES:

NOTE: Analytical data received prior to October 1988 not subjected to validation procedure. Some of the contaminant values reported in this table have not yet been validated, and the analyte list may be changed after the data are validated.

(A) EG&G. February 22, 1991a, Surface Water and Sediment Geochemical Characterization Report, Draft Copy
(B) U.S. DOE. April 2, 1990c, Final Phase II Remedial Investigation/Feasibility Study Workplan (Alluvial), OU2, Draft Copy
(C) U.S. DOE. January 11, 1991a, Proposed Surface Water Interim Measures, Interim Remedial Action Plan/Environmental Assessment and Decision Document South Walnut Creek Basin, OU2, Final Draft
(D) U.S. DOE. January 24, 1991b, Phase II Remedial Investigation/Feasibility Study Workplan (Bedrock), OU2, Draft Copy
(E) U.S. DOE. October, 1990d, Phase III Remedial Investigation/Feasibility Study Workplan 881 Hillside Area, OU1, Final Draft
(F) EG&G. March 1, 1991b, 1990 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant, Draft Copy
(G) EG&G. May, 1991, Unpublished data (See NOTE to references)

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